federal register

TUESDAY, JANUARY 13, 1976

PART II:

ENVIRONMENTAL PROTECTION AGENCY

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NEW MOTOR VEHICLES AND NEW MOTOR VEHICLE ENGINES: CERTIFICATION AND TEST PROCEDURES

Proposed Evaporative Emission Regulations

ENVIRONMENTAL PROTECTION AGENCY

[40 CFR Part 86]

[FRL-472-3]

NEW MOTOR VEHICLES AND NEW MOTOR VEHICLE ENGINES: CERTIFICATION AND TEST PROCEDURES

Proposed Evaporative Emission Regulations for Light Duty Vehicles and Trucks

The Environmental Protection Agency (EPA) is proposing amendments to Subparts A and B of Part 86 of the Code of Federal Regulations (CFR) to become effective beginning with the 1978 model year, applicable to light duty vehicles and light duty trucks. These amendments would: (1) revise the evaporative emission portions of the test procedure and establish revised evaporative emission standards; (2) establish evaporative emission families; and (3) make non-substantive changes to Subpart B, including the overall organization and certain aspects of the exhaust emission portions of the text procedure.

Evaporative Emission Test Procedure and Standards. Fuel evaporative hydrocarbon emissions have been studied and measured since 1958. Federal control of evaporative emission levels was first proposed in the Federal Register (32 FR 2448) in 1967 where a novel and relatively untried measurement procedure, use of a vehicle enclosure, was proposed. These rules would have become effective for the 1969 model year. Final rule making was published in 1968 (33 FR 8304) where the novel measurement procedure was abandoned in favor of a better known procedure which utilizes the adsorption of hydrocarbon on activated charcoal (carbon trap method) which is weighed before and after the test to determine the mass of hydrocarbon adsorbed. Because of manufacturing lead time requirements, the implementation of the standards was delayed until the 1971 model year, and the emission level was set at 6 g/test. The evaporative emission standard was then reduced to a 2 g/test for 1972 and subsequent model years.

The current carbon trap method for measuring evaporative emissions has been found through testing with a more accurate measurement method to greatly underestimate actual evaporative emissions. The more accurate testing method is the Society of Automotive Engineers (SAE) recommended procedure for measuring evaparative emissions (SAE J171a) and involves collecting the evaporative emissions in a large sealed enclosure containing the test vehicle. The results of the most recent EPA in-use vehicle testing program (1973) by the enclosure method showed evaporative emissions to be at a 31 g/test level which is about 15 times the 2 g/test standard which must currently be met when testing is done by the "carbon trap" method. When this emission level is converted to a grams per mile equivalent, the resultant level is about 2.5 g/mile as compared to the current Federal exhaust emission standard of 1.5 g/mile and the statutory goal of 0.4 g/mile.

In April, 1975, the State of California requested a waiver of Federal preemption under section 209(b) of the Clean Air Act to enable California to enforce a light duty vehicle and light duty truck evaporative emission standard for the 1977 and subsequent model years of 6 g/test, as measured by the vehicle enclosure technique. The resultant waiver decision, published in the Federal Register on July 18, 1975, denied the waiver for 1977, but granted it for 1978 and subsequent model years subject to review for continuing satisfaction of the statutory requirements at such time as a new EPA standard is promulgated. At that time EPA announced that it would make all reasonable efforts to accelerate the previously announced schedule and establish a Federal vehicle enclosure regulation for 1978 instead of 1979.

The May 28, 1975 California evaporative emission waiver hearing established that a 6 g/test standard can be met for 1978 production. The technological feasibility of a 2 g/test standard for 1979 model year is supported by the waiver hearing record and by data developed by EPA. This information includes test results which show that the 1975 production Vega, a fuel injected Volkswagen, and a 1974 Plymouth Duster currently generate evaporative emissions below 2 g/test when tested by the proposed test method and that purged canisters can control diurnal emissions to below 0.5 g/test, including any vehicle background emissions. From an assessment of the information currently available regarding evaporative emission control technology, it is the judgment of EPA's technical staff that, given the lead time for technology application to other vehicles that is available with a 1979 standard, a 2 g/test standard can be met for that model year.

The proposed action would establish the enclosure method as the Federal evaporative emission test procedure and would require 1978 model year vehicles to meet a 6 g/test standard and 1979 and later model year vehicles to meet a 2 g/test standard. The levels of these standards are not lower than the present evaporative emission standard but, when required to be met as measured by the enclosure method, would reduce evaporative hydrocarbon emissions by 70 and 90 percentum, respectively. This action is currently needed since it is projected that many Air Quality Control Regions (AQCR's) will still exceed the ambient air quality standards for oxidants even as late as 1990 with the present control strategies for reducing emissions from mobile and stationary sources.

Major differences between the proposed evaporative emission regulations and either the SAE J171a or, where applicable, the existing procedure are discussed below:

1. The proposed evaporative emission measurement procedure measures all evaporative emissions from a vehicle regardless of source and, thus, measures any non-fuel hydrocarbon evaporative emissions such as hydrocarbons from the vaporization of plasticizers, solvents, and lubricants. The current measurement procedure measures only recognized fuel evaporative emission sources, while neglecting undetected fuel evaporative emission sources and ignoring non-fuel sources. These non-fuel emissions are referred to as vehicle background emissions.

These vehicle background emissions vary with vehicle age and can be as large as 5 to 10 g/test for vehicles less than 10 days old but decrease at an exponential rate until, afted 60 to 90 days or after accelerated ageing, they are quite small (i.e. less than 1 g/test). The only means of excluding non-fuel evaporative emissions from the test results is either to separately measure and subtract the non-fuel evaporative emissions, or to give the manufacturers an allowance (correction factor) for non-fuel emissions. A separate measurement of only non-fuel evaporative emissions involves eithed removing or drying out the fuel system and is complicated and costly to perform. Also, for very new vehicles, the resultant measured non-fuel background level could only be used for a short period since the background level is changing rapidly during this period. A reasonably valid correction factor is difficult to specify because of the variability and rapid change in the non-fuel evaporative emissions of new vehicles during the first 60 days. Also, if vehicles with low non-fuel evaporative emissions were used, as is generally the case, the correction factor would serve as a bonus towards meeting the evaporative emission standard. Another consideration in reaching a decision regarding the treatment of, in particular, stabilized non-fuel evaporative emissions is that these emissions are real, continuing hydrocarbon emissions and from an air quality standpoint should be included in the evaporative emissions determination.

Including the small amount of non-fuel evaporative emissions as part of the evaporative emissions to be measured during the certification process is the most straightforward method of handling the non-fuel emissions. No complicated and costly measurements or dubious correction factors are required by this approach. For most test vehicles, non-fuel evaporative emissions are small since manufacturers generally install new drivetrains in currents chassis to construct certification test vehicles. Such chassis can usually be selected to be sufficiently aged to avoid problems of non-fuel evaporative emissions. In addition, the EPA technology assessment gives due consideration to non-fuel emissions in establishing the feasible levels of control. The disadvantage of this approach is that in a few cases the use of a brand new vehicle may be more convenient for the manufacturer; however, this is likely to be a sufficiently rare occurrence so that it will not constitute an unreasonable hardship for the manufacturer. Therefore, these proposed proce-

dures make no special provisions for accounting for vehicle background emissions and include them as part of the measurement.

2. The current evaporative emission test procedure requires that the vehicle be preconditioned by one hour of operation at an average speed of about 35 mph, prior to the preconditioning fuel drain. The driving schedule which is used for this preconditioning is one which was designed for and which is used for rapid mileage accumulation. While the use of this driving schedule provides for convenient extended preconditioning, the schedule does not represent normal urban driving. Tests conducted at the EPA Motor Vehicle Emission Laboratory indicate that this one hour of preconditioning is unnecessary and wasteful. Therefore the proposed test procedure starts with the fuel drain and fill with test fuel which precedes the preconditioning Urban Dynamometer Driving Schedule (UDDS) run. For those unusual circumstances where additional preconditioning is desired, such additional preconditioning may be allowed with the advance approval of the Administrator. For this additional preconditioning the vehicle will be cycled through a cycle consisting of one UDDS followed by a one hour minimum soak for a maximum of three such cycles or until the vehicle's evaporative emission control system reaches a stabilized condition. In addition, gasoline fueled test vehicles may no longer be used to set dynamometer horsepower.

3. Certain phases of the current test procedure require an ambient temperature of 76–86° F while other phases require ambient temperatures of 68–86° or 60–86° F. While good control of ambient conditions is essential to maintain test accuracy, the 76–86° F tolerance is unnecessarily restrictive. The proposed procedures sets a uniform temperature tolerance of 68–86° F for all phases of the test procedure including the enclosure ambient temperature during the diurnal and hot soak test phases. The hot soak specification is reduced from the 90° F allowed by the SAE J171a procedure and corresponds to the specification currently allowed for hot soak testing.

4. The current proucedure and the J171a both allow the diurnal soak to occur during a period of 60±10 minutes. Available data indicate that a time tolerance as wide as ±10 minutes may contribute significantly to test variability. The proposed procedure sets the tolerance of ±2 minutes for the diurnal soak and ±0.5 minute for the hot soak.

5. The SAE J171a procedure specifies that, at the completion of the fuel fill for the diurnal soak, the temperature of the fuel in the tank will be 60±1° F. This may not be possible at some facilities because of the location of the refueling facilities in relation to the location of the enclosures. The proposed procedure allows for fueling of the vehicle with fuel which is between 50 and 60° F and moving the vehicle into the enclosure while the fuel warms up naturally. When all attachments to the vehicle are complete, the enclosure is sealed and the hydrocarbon measurement corresponding to the starting temperature of 60±1° F is used as the enclosure background level for the calculations. This is the simplest possible method for starting the diurnal test and will minimize the number of void tests.

6. The current test procedure specifies the use of iron-constantan (Type J) thermocouples and specifies a temperature recording accuracy of ±1° F. Current industry practice is to use standard grade Type J thermocouples which have an accuracy of ±4° F. Even premium grade Type J thermocouples are only accurate to ±2° F. Recorder error may contribute another ±0.5° F inaccuracy. Current measuring equipment cannot meet the requirements of existing regulations. An absolute accuracy of ±1° is not needed. The proposal specifies an accuracy of ±2° F, which, to be met, requires a change in thermocouple material. The proposed regulations specify the use of copper-constantan (Type T) thermocouples which in a standard grade have an accuracy of ±1.5° F and in premium grade have an accuracy of ±0.75° F.

7. The enclosure method of determining evaporative emissions utilizes the net enclosure volume (enclosure volume minus vehicle volume) in the calculation of evaporative mass emissions. Both the SAE J171a and this proposed procedure use a nominal vehicle volume of 50 ft.³ With a basic enclosure volume of 1,500 ft.³, the nominal vehicle volume represents 3.3% of the enclosure volume. Actual vehicle volumes for very small or very large vehicles might vary from the nominal value by as much as ±25 ft.³ which would change the calculated results by about ±1.7%. Of course, most vehicle volumes would be close to the nominal value so that the added complexity of determining actual vehicle volume is not warranted by the slight improvement in accuracy which would result.

8. The vehicle soak duration between the end of the preconditioning UDDS and the exhaust emission test is specified in this proposal as not less than 12 hours (including the diurnal evaporative emission test) nor more than 36 hours. The time interval between the end of the diurnal test and the start of the exhaust emission test is specified as not to exceed one hour. The time interval between the end of the exhaust test and the beginning of the hot soak is specified as not to exceed five minutes and the time between engine-off and the hot soak is specified as not to exceed one minute.

This means that the diurnal test can be started as soon as the tenth hour of soak (with a one hour delay before the exhaust test) or as late as the thirty-fifth hour of soak (with no delay before the exhaust test). The exhaust test can be started immediately after the completion of the diurnal or can be delayed up to one hour. At the end of the exhaust test, the vehicle is driven to the enclosure and allowed to idle until preparations for pushing it into the enclosure are complete, which can take up to four minutes.

9. The fuel for the FID used to measure evaporative emissions is specified to have a composition of 60% helium and 40% hydrogen containing less than 1 ppm carbon response. The fuel for the FID's used in exhaust emission tests continues unspecified and is not changed from current practice.

10. The concept of evaporative emission certification carryover is continued. However, since this test procedure more accurately assesses evaporative emissions and since, for the same evaporative emission standard, the probability of evaporative-exhaust interactions is thereby increased; the exhaust-only test will also include the one hour diurnal fuel tank heating (need not be done in enclosure) prior to the cold start exhaust emission test. This will allow for proper preconditioning of the evaporative emission control system and correct assessment of evaporative-exhaust interactions during the exhaust emission testing.

11. The proposed regulations allow, with advance approval of the Administrator, additional vehicle cooling during the dynamometer operation if the manufacturer can show that during field operation the vehicle receives additional cooling and that such additional cooling is necessary to provide a representative exhaust or hot soak evaporative test.

Evaporative Emission Families. Motor vehicle manufacturers normally produce many engine, drive-train, emission-system, body-type combinations. The exhaust emission engine family concept was developed to minimize the number of vehicles to be tested to establish the exhaust emission characteristics of a manufacturer's product line. Currently every vehicle which is tested for exhaust emissions is also tested for evaporative emissions. Typically, in all of the various engine families that a manufacturer produces, only a few types of evaporative emission systems are used (perhaps only one for the whole product line). For this reason, the concept of evaporative emission families has been developed as a part of the proposal. The evaporative emission family criteria and vehicle selection criteria are contained in Subpart A. To aid manufacturers in assessing the impact of this new method of designating vehicles to be tested for evaporative compliance, the basic evaporative control system parameters being considered are included.

Evaporative Control System will be defined as a combination of the following:

(A) Method of vapor transmission to the storage device from the vapor source—e.g., continuous or controlled

(B) Adsorbtion material—e.g., carbon, synthetic

(C) Purge Strategy:

1. Continuous, controlled.

2. Point of induction, e.g., carburetor, air cleaner, PCV.

3. Conditioning of purge air, e.g., heated, dried.

(D) Evaporative System Environment Control—e.g., underhood cooling fan, thermostatic vents.

Selecting vehicles for evaporative emission testing according to evaporative emission families will minimize the number of vehicles tested to establish the evaporative emission characteristics of a manufacturer's product line. This change represents a potential time and cost savings for both EPA and the manufacturers.

Non-substantive changes to Subpart B. Introducing into the regulations a new and substantially different evaporative emission test procedure results in a major revision of the regulations. This proposal includes a reorganized emission test procedure (Subpart B) which is structured so that all equipment descriptions are located together, all calibration requirements are located together, and the test procedure follows a logical sequence from beginning to end. In addition, several non-substantive improvements have been made to certain aspects of the exhaust emission portions of the test procedure.

1. The test procedures in subpart B have been reorganized to promote clarity. No substantive changes have been made. Basically, subpart B has been arranged in a logical, essentially time oriented order. Required equipment is listed first with calibration procedures following. The test methods and sample calculations appear at the end.

Along with the general reorganization, many wording changes have also been made. These revisions are intended to clarify, but not change, the test procedure. For example, only differences in the Diesel sampling system are described. Previously two separate, but substantially identical descriptions were included. Another example is the combination of the 3 previous sections dealing with transmissions into one section. In addition, equipment descriptions and schematic drawings have been modified to more closely reflect general performance requirements rather than specific design parameters.

2. Coinciding with the subpart reorganization, a new numbering system for Subpart B is proposed. The model year designation appears as a suffix following the section number and is separated by a hyphen. A section will remain effective until it is superseded. This change will make republishing for each model year unnecessary. Also, when a section is amended for an upcoming model year it will appear following the current section. This will enable the reader to quickly find the changes that have been made.

3. The regulations have been updated to allow use of the critical flow venturi constant volume sampler. A separate calibration procedure is also specified, and the section entitled "chart reading" has been deleted. Manufacturers will not have to request special permission to use this equipment.

4. Specifications for placement of the cooling fan have been relaxed. The cooling fan is now required to be within 12 inches of the vehicle rather than " . . . between 8 and 12 inches in front of the cooling air inlets (grill)".

5. To reflect current commercially available instrument specifications, the operating response time of the heated flame ionization detector (HFID) has been changed from 1 to 1.5 seconds for 90 percent full scale response.

6. To promote better test correlation and minimize test to test variability, tolerance specifications have now been specified for both calibration and span gases including traceability requirements to NBS, EPA or other approved gas standards.

7. The number of calibration gases required for each instrument range of the carbon monoxide and carbon dioxide analyzers have been reduced from 8 to 6, and recommendations for selecting the calibration curves have been described, rather than using "best judgment".

8. The proposed regulations present specifications and equations in customary (English) units, with System International (SI) units in parenthesis to provide additional information and to aid in the orderly transition to the metric system.

Interested persons are invited to participate in the making of the proposed rule by submitting such written data, views or arguments as they may desire. In order that EPA may evaluate the relationship between air quality improvement and socioeconomic impact, the manufacturers are requested to supply data to indicate the lead time required and the cost per vehicle of compliance with a standard of 6 g/test for 1978 and a 2 g/test standard for 1979 when testing by the proposed procedure. A detailed breakdown of component costs is requested. Comments are also requested on the new evaporative emission family and vehicle selection criteria both in terms of the potential savings to be realized and in terms of problems that may arise due to the integration of the proposal into the existing certification scheme. In addition, comments are solicited regarding the arrangement, duration specifications and parameter tolerances of the various parts of the evaporative emission test procedure. Comments are also solicited regarding the utility of the rearranged Subpart B.

Communications should be submitted (in quadruplicate) to the Administrator, Environmental Protection Agency, Attention: Office of Mobile Source Air Pollution control, 401 M Street SW., Washington, D.C. 20460. All relevant material received on or before February 23, 1976 will be considered. Comments submitted shall be available for public inspection during normal business hours at the Office of Public Affairs, Environmental Protection Agency, 4th and M Streets SW., Washington, D.C.

A copy of all public comments and draft environmental impact statement will be available for inspection and copying at the U.S. Environmental Protection Agency, Public Information Reference Unit, Room 2922 (EPA Library) 401 M Street SW., Washington, D.C. 20460. As provided in 40 CFR Part 2, a reasonable fee may be charged for copying services.

This Notice of proposed rulemaking is issued under authority of sections 202, 206, 207, 208, and 301(a) of the Clean Air Act, as amended (42 U.S.C. 1857f–1, 1857f–5, 1857f–5a, 1857f–6, and 1857g (a)).

It is hereby certified that the economic and inflationary impacts of this proposed regulation have been carefully evaluated in accordance with Executive Order 11821.

Dated: December 31, 1975.

JOHN QUARLES,
Acting Administrator.

It is proposed to amend Part 86 of Chapter I, Title 40 of the Code of Federal Regulations by revising Subparts A and B as follows:

Subpart A—General Provisions for Emission Regulations for 1977 and Later Model Year New Light Duty Vehicles, 1977 and Later Model Year New Light Duty Trucks and for 1977 and Later Model New Heavy Duty Engines

1. A new § 86.078–2 is added and reads as follows:

§ 86.078–2 Definitions.

The following definitions apply beginning with the 1978 model year. Section 86.077–2 remains effective excepting those definitions which are hereby superseded.

"Diurnal breathing losses" means evaporative emissions as a result of the daily range in temperature.

"Engine—system combination" means an engine family-exhaust emission control system combination.

"Evaporative emissions" means hydrocarbons emitted into the atmosphere from a motor vehicle, other than exhaust and crankcase emissions.

"Hot soak losses" means evaporative emissions after termination of engine operation.

"Tank fuel volume" means the volume of fuel in the fuel tank(s), which is determined by taking the manufacturer's nominal tank(s) capacity and multiplying by 40%, the result being rounded to the nearest tenth of a U.S. gallon.

"Fuel system" means the combination of fuel tank(s), fuel pump, fuel lines, and carburetor or fuel injection components, and includes all fuel system vents and fuel evaporative emission control systems.

2. A new § 86.078–3 is added and reads as follows:

§ 86.078–3 Abbreviations.

(a) The abbreviations in this section apply to this subpart and also to subparts B, H, I, and J.

(b) The abbreviations used in this subpart have the following meanings in both capital and lower case:

Accel.—Acceleration.
AECD—Auxiliary Emission Control Device.
API—American Petroleum Institute.
ASTM—American Society for Testing and Materials.
BHP—Brake horsepower.

BSCO—Brake specific carbon monoxide
BSHC—Brake specific hydrocarbons.
BSNOx—Brake specific oxides of nitrogen.
C—Celsius.
cfh—Cubic feet per hour.
CFV—Critical flow venturi.
CL—Chemiluminescence.
CO_2—Carbon dioxide.
CO—Carbon monoxide.
Conc.—Concentration.
cfm—Cubic feet per minute.
CT—Closed Throttle.
cu. in.—Cubic inch(es).
CVS—Constant volume sampler.
Decel.—Deceleration.
EP—End point.
Evap.—Evaporated.
F—Fahrenheit.
FID—Flame ionization detector.
FL—Full load.
gal.—U.S. gallon(s).
g—Grams.
GVW—Gross Vehicle Weight.
H_2O—Water.
HC—Hydrocarbon(s).
HFID—Heated flame ionization detector.
Hg—Mercury.
Hi.—High.
Hp—Horsepower.
Hr—Hour.
IBP—Initial boiling point.
ID—Internal diameter.
kPa—Kilopascal(s).
Lb.—Pound(s).
LFE—Laminar flow element.
Lb ft—Pound-feet.
m—Metre.
Max.—Maximum.
Min.—Minimum.
Min.—Minute(s).
ml—Milliliter(s).
mph—Miles per hour.
mm—Millimeter(s).
mv—Millivolt(s).
N_2—Nitrogen.
NDIR—Nondispersive infrared.
NO—Nitric oxide.
NO_2—Nitrogen dioxide.
NOx—Oxides of nitrogen.
No.—Number.
Pb—Lead.
PDP—Positive displacement pump.
ppm—Parts per million by volume.
ppm C—Parts per million, carbon.
psi—Pounds per square inch.
psig—Pounds per square inch gauge.
PTA—Part throttle acceleration.
PTD—Part throttle deceleration.
R—Degrees Rankin.
rpm—Revolutions per minute.
RVP—Reid vapor pressure.
S.A.E.—Society of Automotive Engineers.
s—Second(s).
SI—System international.
Sp.—Speed.
SS—Stainless steel.
t—time.
TEL—Tetraethyl lead.
TML—Tetramethyl lead.
v—Volts.
Vs—Versus.
w—watt.
WF—Weighting factor.
WOT—Wide open throttle.
Wt—Weight.
'—Feet.
"—Inches.
°—Degrees.
%—Percent.
Σ—Summation.

3. Paragraph (b) of § 86.078–8 is revised to read as follows:

§ 86.078–8 Emission standards for 1978 light duty vehicles.

* * * * *

(b)(1) Evaporative emissions from gasoline fueled light duty vehicles shall not exceed:

(i) *Hydrocarbons.* 6.0 grams per test.

(2) The standard set forth in paragraph (b)(1) of this section refers to a composite sample of the evaporative emissions collected under the conditions set forth in subpart B and measured in accordance with those procedures.

* * * * *

4. A new § 86.078–9 is added and reads as follows:

§ 86.078–9 Emission standards for 1978 light duty trucks.

(a) [See Paragraph (a) of § 86.077–9]

(b)(1) Evaporative emissions from 1978 model year gasoline fueled light duty trucks shall not exceed:

(i) *Hydrocarbons.* 6.0 grams per test.

(2) The standard set forth in paragraph (b)(1) of this section refers to a composite sample of the evaporative emissions collected under the conditions set forth in subpart B and measured in accordance with those procedures.

(c) [See Paragraph (c) of § 86.077–9]

5. A new section § 86.079–8 is added and reads as follows:

§ 86.079–8 Emission standards for 1979 light duty vehicles.

(a) [See paragraph (a) of § 86.077–9]

(b)(1) Evaporative emissions from 1979 model year gasoline fueled light duty vehicles shall not exceed:

(i) *Hydrocarbons.* 2 grams per test.

(2) The standard set forth in paragraph (b)(1) of this section refers to a composite sample of the evaporative emissions collected under the conditions set forth in subpart B and measured in accordance with those procedures.

(c) [See Paragraph (c) of § 86.077–8]

6. A new § 86.079–9 is added and reads as follows:

§ 86.079–9 Emission standards for 1979 light duty trucks.

(a) [See Paragraph (a) of § 86.077–9]

(b)(1) Evaporative emissions from 1979 model year gasoline fueled light duty trucks shall not exceed:

(i) *Hydrocarbons.* 2 grams per test.

(2) The standard set forth in paragraph (b)(1) of this section refers to a composite sample of the evaporative emissions collected under the conditions set forth in subpart B and measured in accordance with those procedures.

(c) [See Paragraph (c) of § 86.077–9]

7. A new § 86.078–24 is added and reads as follows:

§ 86.078–24 Test vehicles and engines.

(a)(1) through (a)(4) [See paragraphs (a)(1) through (a)(4) of § 86.077–24]

(5) The gasoline fueled vehicles covered by an application for certification will be divided into groupings which are expected to have similar evaporative emission characteristics throughout their useful life. Each group of vehicles with similar evaporative emission characteristics shall be defined as separate evaporative family.

(6) To be classed in the same evaporative family, vehicles must be identical in all of the following respects:

(i) Vapor storage device (e.g., canister, air cleaner, crankcase, induction system).

(ii) Basic canister design, including:

(A) Design working capacity (e.g., vapor adsorption capacity)

(B) Housing Material

(C) Configuration (e.g., open bottom, closed bottom, purge control valves)

(iii) Carburetor model or fuel injection type (including features such as external carburetor bowl vents and purge control valves).

(iv) Basic fuel tank type (e.g., hollow steel, vapor control baffles, plastic lined).

(v) Basic fuel filler cap type (e.g., seal mechanism, retention mechanism).

(7) Where vehicles are of a type which cannot be divided into evaporative families based on the criteria listed above, the Administrator will establish families for those vehicles based upon the features most related to their evaporative emission characteristics.

(b)(1)(i) [See paragraph (b)(1)(i) of § 86.077–24]

(ii) Vehicles of each engine family will be divided into engine displacement-exhaust emission control system combinations as applicable. A projected sales volume will be established for each combination for the model year for which certification is sought. One vehicle of each combination will be selected in order of decreasing projected sales volume until 70 percent of the projected sales of a manufacturer's total production of vehicles of that engine family is represented, or until a maximum of four vehicles is selected. If any single combination represents over 70 percent, then two vehicles of that combination may be selected. The vehicle selected for each combination will be specified by the Administrator as to transmission type, fuel system, and inertia weight class.

(iii) through (vi) [See paragraphs (b)(1)(iii) through (b)(1)(vi) of § 86.077–24]

(vii)(A) Vehicles of each evaporative family will be divided into evaporative control systems. One vehicle of each evaporative control system within the evaporative family will be selected.

(B) The Administrator may select a maximum of four (4) additional vehicles within each evaporative family based upon features indicating that they may have the highest evaporative emission levels of vehicles in that family.

(C) Vehicles selected under (b)(1)(i) through (vi) may be used to satisfy the requirements of (b)(1)(vii) (A) and (B).

(D) The Administrator will also select one vehicle for each evaporative control system within each evaporative family for which vehicles are to be sold at high altitude.

(E) Vehicles selected under (b)(1)(v) may be used to satisfy the requirements of (b)(1)(vii)(D).

(b)(2) through (c)(1)(ii) [See paragraphs (b)(2) through (c)(1)(ii) of § 86.077–24]

(iii) A durability vehicle will be selected by the Administrator to represent each evaporative control system within each evaporative family. Vehicles selected under (c)(1)(i) will be used to satisfy the requirements of this section. If it is impossible for any vehicle selected under the constraints of (c)(1)(i) to satisfy the requirements of this section, then an additional durability vehicle may be selected to satisfy the evaporative durability requirements.

(iv) Exhaust durability data (§ 86.178–5(b)) from any vehicle selected under this paragraph to satisfy evaporative durability requirements will be used according to § 86.078–28(a)(4)(i)(A)(1) with the exhaust durability data from the vehicle selected under (c)(1)(i) for the same engine-system combination.

(c)(2) through (e) [See paragraphs (c)(2) through paragraph (e) of § 86.007–24].

(f) In lieu of testing an emission data or durability data vehicle (or engine) selected under paragraph (b) or (c) of this section, and submitting data therefor, a manufacturer may, with the prior written approval of the Administrator, submit exhaust emission data and/or evaporative emission data, as applicable on a similar vehicle (or engine) for which certification has previously been sought.

(g) [See paragraph (g) of § 86.077–24].

8. A new § 86.078–26 is added and reads as follows:

§ 86.078–26 Mileage and service accumulation; emission measurements.

(a)(1) and (a)(2) [See paragraphs (a)(1) and (a)(2) of § 86.077–26].

(3) Emission data vehicles.

(i) *Gasoline-fueled.* (A) Each gasoline-fueled emission data vehicle shall be driven 4000 miles with all emission control systems installed and operating. Complete exhaust emission tests shall be conducted at zero miles and 4000 miles on those vehicles selected under 86.078–24(b). Complete exhaust emission and evaporative emission tests shall be conducted at 4000 miles on those vehicles selected under 86.078–24(c) unless the Administrator determines under 86.078–24(f) that only the exhaust emission test shall be conducted at zero miles and 4000 miles.

(a)(3)(i)(B) through (c) [See paragraphs (a)(3)(i)(B) through (c) of § 86.077–26].

9. A new § 86.078–28 is added and reads as follows:

§ 86.078–28 Compliance with emission standards.

(a)(1) through (a)(3) [See paragraphs (a)(1) through (a)(3) of § 86.077–28].

(4) The procedure for determining compliance of a new motor vehicle with exhaust and evaporative emission standards, as applicable, is as follows:

(i) Separate emission deterioration factors shall be determined from the emission results of the durability data vehicle(s) for each engine-system combination. A separate factor shall be established for exhaust HC, exhaust CO, exhaust NOx for each engine-system combination. Separate evaporative deterioration factors shall be determined from the evaporative emission results of the durability vehicle(s) for each evaporative control system within each evaporative family.

(a)(4)(i)(A) through (a)(4)(i)(C) [See paragraphs (a)(4)(i)(A) through (a)(4)(i)(C) of § 86.077–28].

(D) For gasoline-fueled vehicles, an evaporative emission deterioration factor shall be calculated for each evaporative control system within each evaporative family, by subtracting the evaporative emissions interpolated to 4,000 miles from the evaporative emissions interpolated to 50,000 miles. These interpolated values shall be carried out, in accordance with ASTM E 29–67, to a minimum of three decimal places to the right of the decimal point before subtracting one from the other to determine the deterioration factor.

(a)(4)(ii)(A) through (c) [See paragraphs (a)(4)(ii)(A) through (c) of § 86.077–28].

10. A new § 86.078–30 is added and reads as follows:

§ 86.078–30 Certification.

(a)(1) and (a)(2) [See paragraphs (a)(1) and (a)(2) of § 86–077–30].

(3) One such certificate will be issued for each engine family-evaporative family combination and will certify compliance with no more than one set of applicable standards.

(a)(4) through (a)(6) [See paragraphs (a)(4) through (a)(6) of § 86.077–30]

(b)(1) The Administrator will determine whether a vehicle (or engine) covered by the application complies with applicable standards by observing the following relationships:

(i) Light duty vehicles and light duty trucks.

(A) A test vehicle selected under § 86.078–24(b)(1)(ii) or (iv) shall represent all vehicles in the same engine family of the same engine displacement-exhaust emission control system combination as applicable to be sold below 4,000 ft. in elevation. A test vehicle selected under § 86.078–24(b)(1)(vii)(A) or § 86.078–24(b)(1)(vii)(B) shall represent all vehicles in the same evaporative control system within the evaporative family as applicable, to be sold below 4,000 ft. in elevation.

(b)(1)(i)(B) [See paragraph (b)(1)(i)(B) of § 86.077–30]

(C) A test vehicle selected under § 86.078–24(c)(1)(iii) shall represent all vehicles in the same evaporative control system within the evaporative family.

(D) A test vehicle selected under § 86.078–24(b)(1)(vii)(D) shall represent all the vehicles of the same evaporative control system within the evaporative family to be sold at high altitude.

(b)(1)(iii) through (c) [See paragraphs (b)(1)(iii) through (c) of § 86.077–30]

11. A new § 86.078–35 is added and reads as follows:

§ 86.078–35 Labeling.

(a)(1)(iii)(D) through (b) [See paragraphs (a) through (a)(1)(iii)(B) of § 86.077–35]

(C) Engine displacement (in cubic inches), engine family identification and evaporative family identification.

(a)(1)(iii)(D) through (b) [See paragraph (a)(1)(iii)(D) through paragraph (b) of § 86.077–35]

12. Subpart B is enlarged by adding §§ 86.101–78 through 86.139–78 (effective for the 1978 model year) which reads as follows:

Subpart B—Emission Regulations for 1977 and Later Model Year New Light Duty Vehicles and New Light Duty Trucks; Test Procedures

Sec.

86.101–78 Applicability.
86.102–78 Definitions.
86.103–78 Abbreviations.
86.104–78 Section numbering, construction.
86.105–78 Introduction; structure of subpart.
86.106–78 Equipment required; overview.
86.107–78 Sampling and analytical system, evaporative emissions.
86.108–78 Dynamometer.
86.109–78 Exhaust Gas sampling system.
86.110–78 Exhaust Gas analytical system.
86.111–78 Fuel specifications.
86.112–78 Analytical gases.
86.113–78 EPA Urban Dynamometer Driving Schedule.
86.114–78 Calibrations, frequency and overview.
86.115–78 Evaporative emission enclosure calibrations.
86.116–78 Dynamometer calibraton.
86.117–78 Constant volume samper calibration.
86.118–78 Hydrocarbon analyzer calibration.
86.119–78 Carbon monoxide analyzer calibration.
86.120–78 Oxides of nitrogen analyzer calibration.
86.121–78 Carbon dioxide analyzer calibration.
86.122–78 Calibration of other equipment.
86.123–78 Test procedures, overview.
86.124–78 Transmissions.
86.125–78 Road load power and inertia weight determination.
86.126–78 Test sequence, general requirements.
86.127–78 Vehicle preparation.
86.128–78 Vehicle preconditioning.
86.129–78 Diurnal breathing loss test.
86.130–78 Running loss test.
86.131–78 Dynamometer procedure.
86.132–78 Engine starting and restarting.
86.133–78 Dynamometer test runs.
86.134–78 Hot soak test.
86.135–78 Exhaust sample analysis.
86.136–78 Records required.
86.137–78 Calculations; evaporative emissions.
86.138–78 Calculations; exhaust emissions.

AUTHORITY: Sec. 202, 206, 207, 208, and 301(a) of the Clean Air Act, as amended (42 U.S.C. 1857F–1, 1857F–5, 1857F–5a, 1857F–6, 1857g(a)).

Subpart B—Emission Regulations for 1977 and Later Model Year New Light Duty Vehicles and New Light Duty Trucks; Test Procedures

§ 86.101–78 General applicability.

(a) The provisions of this subpart are applicable to 1977 and later model year new light duty vehicles and light duty trucks.

(1) Sections 86.101–78 through 86.139–78 apply for 1978 and later model years.

(2) Sections 86.177–1 through 86.177–23 apply for the 1977 model year only.

(b) Provisions of this subpart apply to tests performed by both the Administrator and motor vehicle manufacturers.

§ 86.102–78 Definitions.

The definitions in §§ 86.077–2 and 86.078–2 apply to this subpart.

§ 86.103–78 Abbreviations.

The abbreviations in § 86.078–3 apply to this subpart.

§ 86.104–78 Section numbering, construction.

(a) The model year of initial applicability is indicated by the section number. The two digits following the hyphen designate the first model year for which a section is effective. A section remains effective until superseded.

EXAMPLE: Section 86.111–78 applies to the 1978 and subsequent model years until superseded. If a section 86.111–81 is promulgated it would take effect beginning with the 1981 model year; § 86.111–78 would apply to model years 1978 through 1980.

(b) Unless indicated, all provisions in this subpart apply to both gasoline and diesel fueled vehicles.

§ 86.105–78 Introduction, structure of subpart.

(a) This subpart describes the equipment required and the procedures to follow in order to perform exhaust and evaporative emission tests on light duty vehicles and light duty trucks. Subpart A sets forth the testing requirements and test intervals necessary to comply with EPA certification procedures.

(b) Three topics are addressed in this subpart. Sections 86.106 through 86.113 set forth specifications and equipment requirements; §§ 86.114 through 86.122 discuss calibration methods and frequency; test procedures and data requirements are listed (in approximately chronological order) in §§ 86.123 through 86.139.

§ 86.106–78 Equipment required; overview.

(a) This subpart contains procedures for both exhaust and evaporative emissions tests on gasoline or diesel fueled light duty vehicles and light duty trucks. Certain items of equipment are not necessary for a particular test, e.g., evaporative enclosure when testing diesel vehicles. Equipment required and specifications are as follows:

(1) *Evaporative emission tests, gasoline fueled vehicles.* The evaporative emission test is closely related to and connected with the exhaust emission test. All vehicles tested for evaporative emissions must be tested for exhaust emissions. Further, unless the evaporative emission test is waived by the Administrator under § 86.077–26, all gasoline fueled vehicles must undergo both tests. (Diesel vehicles are excluded from the evaporative emission standard.) Section 86.107 specifies the necessary equipment.

(2) *Exhaust emission tests.* All vehicles subject to this subpart are tested for exhaust emissions. Diesel and gasoline fueled vehicles are tested identically with the exception of hydrocarbon measurements; diesel vehicles require a heated hydrocarbon detector, §86.109. All gasoline fueled vehicles are either tested for evaporative emissions or undergo a diurnal heat build, diesel vehicles are excluded from this requirement. Equipment necessary and specifications appear in sections 86.108 through 86.112.

(3) *Fuel, analytical gas, and driving schedule specifications.* Fuel specifications for exhaust and evaporative emission testing and for mileage accumulation for gasoline and diesel fueled vehicles are specified in § 86.111–78. Analytical gases are specified in § 86.112. The EPA Urban Dynamometer Driving Schedule for use in exhaust testing is specified in § 86.113 and Appendix I.

§ 86.107–78 Sampling and analytical system, evaporative emissions.

(a) Component description (evaporative emissions sampling system). The following components will be used in evaporative emissions sampling systems for testing under this subpart.

(1) *Evaporative emission measurement enclosure.* The enclosure shall be large enough to accommodate the largest vehicle to be tested, with space for personnel access to all sides of the vehicle. The enclosure door must allow entry of the maximum size vehicle. When sealed, the enclosure shall be gas tight. Interior surfaces must be impermeable to hydrocarbons. One surface should be of flexible, impermeable material to allow for minor volume changes, resulting from temperature changes. To maximize dissipation of heat, wall materials should be of minimum thermal resistance.

(2) *Evaporative emission hydrocarbon analyzers.* A hydrocarbon analyzer utilizing the hydrogen flame ionization principle (FID) shall be used to monitor the atmosphere within the enclosure. The FID shall have a minimum full scale measuring sensitivity of 5 ppm propane with a stability of ±1% of range, a reproducibility of ±1% of range and a response to 90% of final reading within 1.5 s. Sufficient ranges will be available, such that any reading will fall within the upper 80% of the range in use.

(3) *Evaporative emission hydrocarbon data recording system.* The electrical output of the FID shall be recorded at the initiation and termination of each diurnal or hot soak. The recording may be by means of a strip chart potentiometric recorder, by use of an on-line computer system or other suitable means. In any case, the recording system must have operational characteristics (signal to noise ratio, speed of response, etc.) equivalent to or better than those of the signal source being recorded, and must provide a permanent record of results. The recording system must provide a positive indication of the initiation and completion of each diurnal or hot soak along with the time elapsed between initiation and completion of each soak.

(4) *Tank fuel heating system.* The tank fuel heating system shall consist of a heat source and a temperature controller. A typical heat source is a 2,000 w heating pad. Other sources may be used as required by circumstances. The temperature controller may be manual, such as a variable voltage transformer, or may be automated. The heating system must not cause hot spots on the tank wetted surface which could cause local overheating of the fuel. Heat must not be applied to the vapor in the tank above the liquid fuel. The temperature controller must be capable of controlling the fuel tank temperature during the diurnal soak to within ±2° F (1.1° C) of the following equation:

$$F = 60 + 0.4\,t$$

or for SI units:

$$C = 15.556 + (2/9)\,t$$

Where:

F = Temperature in °F
C = Temperature in °C
t = Time since start of test in minutes

(5) *Temperature recording system.* Strip chart recorder(s) or automatic data processor shall be used to record enclosure ambient and vehicle fuel tank temperature during the evaporative emissions test. The temperature recorder or data processor shall record each temperature at least once every minute. The recording system shall be capable of resolving time to ±15 s and capable of resolving temperature to ±0.75° F (0.42° C). The temperature recording system (recorder and sensor) shall have an accuracy of ±2° F (1.1° C). The recorder (data processor) shall have a time accuracy of ±15 s and a precision of ±15 s. The ambient temperature sensor shall be located in the enclosure, within 6 inches (15 cm) of the geometric center of the ceiling and between 6 and 12 in. (15 and 30 cm) below the ceiling surface. The vehicle fuel tank temperature sensor shall be located in the fuel tank so as to measure the temperature of the prescribed test fuel at its approximate mid-volume of the fuel. Manufacturers shall arrange that vehicles furnished for testing at Federal certification facilities be equipped with copper-constantan Type T thermocouples for measurement of fuel tank temperature.

(6) *Purge blower.* One or more portable or fixed blowers shall be used to purge the enclosure. The blowers shall have sufficient flow capacity to reduce the enclosure hydrocarbon concentration from the test level to the ambient level between tests. Actual flow capacity will depend upon the time available between tests.

(7) *Mixing blower.* One or more small blowers or fans shall be used to mix the contents of the enclosure during evaporative emission testing. Maintenance of uniform concentrations throughout the enclosure is important to the accuracy of the test.

§ 86.108–78 Dynamometer.

The dynamometer shall have a power absorbtion unit for simulation of road load power and flywheels or other means of simulating the inertia weight as specified in § 86.125.

§ 86.109–78 Exhaust gas sampling system.

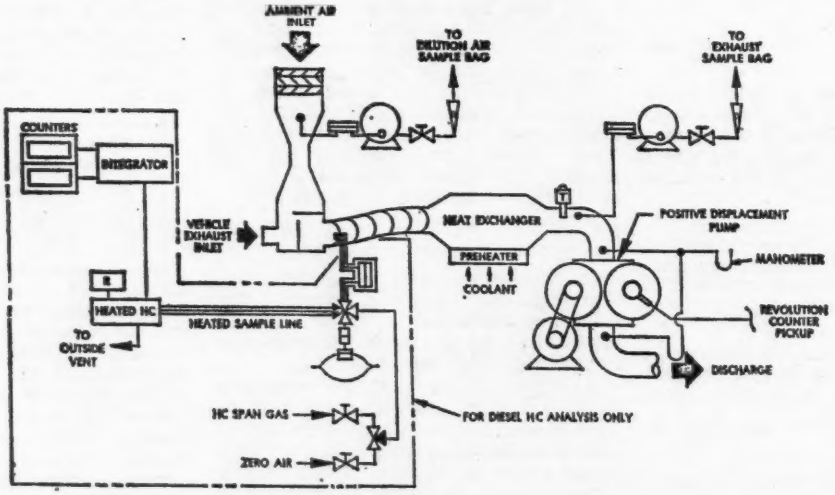
(a)(1) *Schematic drawings.* Figure B78–1 is a schematic drawing of the Positive Displacement Pump-Constant Volume Sampler (PDP–CVS) and Figure B78–2 is a schematic drawing of the Critical Flow Venturi-Constant Volume Sampler (CFV–CVS). These are two suggested exhaust gas sampling systems.

(2) Since various configurations can produce equivalent results, exact conformance with either drawing is not required. Additional components such as instruments, valves, solenoids, pumps, and switches may be used to provide additional information and coordinate the functions of the component systems.

(3) *Other Systems.* Other sampling systems may be used if shown to yield equivalent results and if approved in advance by the Administrator.

(b) *Component description, PDP–CVS.* The PDP–CVS, Figure B78–1, consists of a dilution air filter and mixing assembly, heat exchanger, positive displacement pump, sampling system, and associated valves, pressure and temperature sensors.

The PDP–CVS shall conform to the following requirements:



(SEE FIG. B78-3 FOR SYMBOL LEGEND)
FIGURE B78-1 —EXHAUST GAS SAMPLING SYSTEM (PDP-CVS)

(1) Static pressure variations at the tailpipe(s) of the vehicle shall remain within ±5 inches of water (1.2 kPa) of the static pressure variations measured during a dynamometer driving cycle with no connection to the tailpipe(s). (Sampling systems capable of maintaining the static pressure to within ±1 inch of water (0.25 kPa) will be used by the Administrator if a written request substantiates the need for this closer tolerance.)

(2) The gas mixture temperature, measured at a point immediately ahead of the positive displacement pump, shall be within ±10° F (5.6° C) of the designed operating temperature at the start of the test. The gas mixture temperature variation from its value at the start of the test shall be limited to ±10° F (5.6° C) during the entire test. The temperature measuring system shall have an accuracy and precision of ±2° F (1.1°C).

(3) The pressure gauges shall have an accuracy and precision of ±3 mm Hg (0.4 kPa).

(4) The flow capacity of the CVS shall be large enough to eliminate water condensation in the system (300 to 350 cfm, 0.142 to 0.165 m^3/s, is sufficient for most vehicles).

(5) Sample collection bags for dilution air and exhaust samples shall be of sufficient size so as not to impede sample flow.

(c) *Component description, CFV–CVS.* The CFV–CVS, Figure B78–2 consists of a dilution air filter and mixing assmbly, cyclone particulate separator, sampling venturi, critical flow venturi, sampling system, and assorted valves, pressure and temperature sensors. The CFV–CVS shall conform to the following requirements:

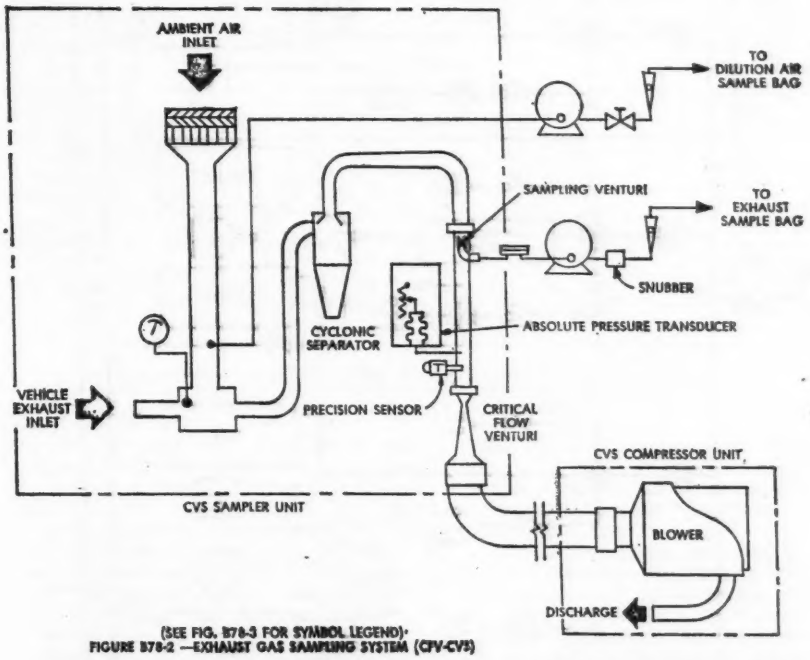
(1) Static pressure variations at the tailpipe(s) of the vehicle shall remain within ±5 inches of water (1.2 kPa) of the static pressure variations measured during a dynamometer driving cycle with no connection to the tailpipe(s). (Sampling systems capable of maintaining the static pressure to within ±1 inch of water (0.25 kPa) will be used by the

Administrator if a written request substantiates the need for this closer tolerance.)

(2) The temperature measuring system shall have an accuracy and precision of ±2° F (1.1° C) and a response time of 0.100 s to 62.5% of a temperature change.

(3) The pressure measuring system shall have an accuracy and precision of ±3 mm Hg (0.4 kPa).

(4) The flow capacity of the CVS shall be large enough to eliminate water condensation in the system (300 to 350 cfm, 0.142 to 0.165 m^3/s, is sufficient for most vehicles).



(SEE FIG. B78-3 FOR SYMBOL LEGEND)
FIGURE B78-2 —EXHAUST GAS SAMPLING SYSTEM (CFV-CVS)

(5) Sample collection bags for dilution air and exhaust samples shall be of sufficient size so as not to impede sample flow.

§ 86.110–78 Exhaust gas analytical system.

(a) *Schematic drawings.* Figure B78–3 is a schematic drawing of the exhaust gas analytical system. The schematic of the hydrocarbon analysis train for diesel fueled vehicles is shown as part of Figure B78–1. Since various configurations can produce accurate results, exact conformance with either drawing is not required. Additional components such as instruments, valves, solenoids, pumps and switches may be used to provide additional information and coordinate the functions of the component systems.

(b) *Major component description.* The analytical system, Figure B78–3, consists of a flame ionization detector (FID) for the determination of hydrocarbons, nondispersive infrared analyzers (NDIR) for the determination of carbon monoxide and carbon dioxide and a chemiluminescence analyzer (CL) for the determination of oxides of nitrogen. A heated flame ionization detector (HFID) is used for the continuous determination of hydrocarbons from diesel fueled vehicles, Figure B78–1. The exhaust gas analytical system shall conform to the following requirements:

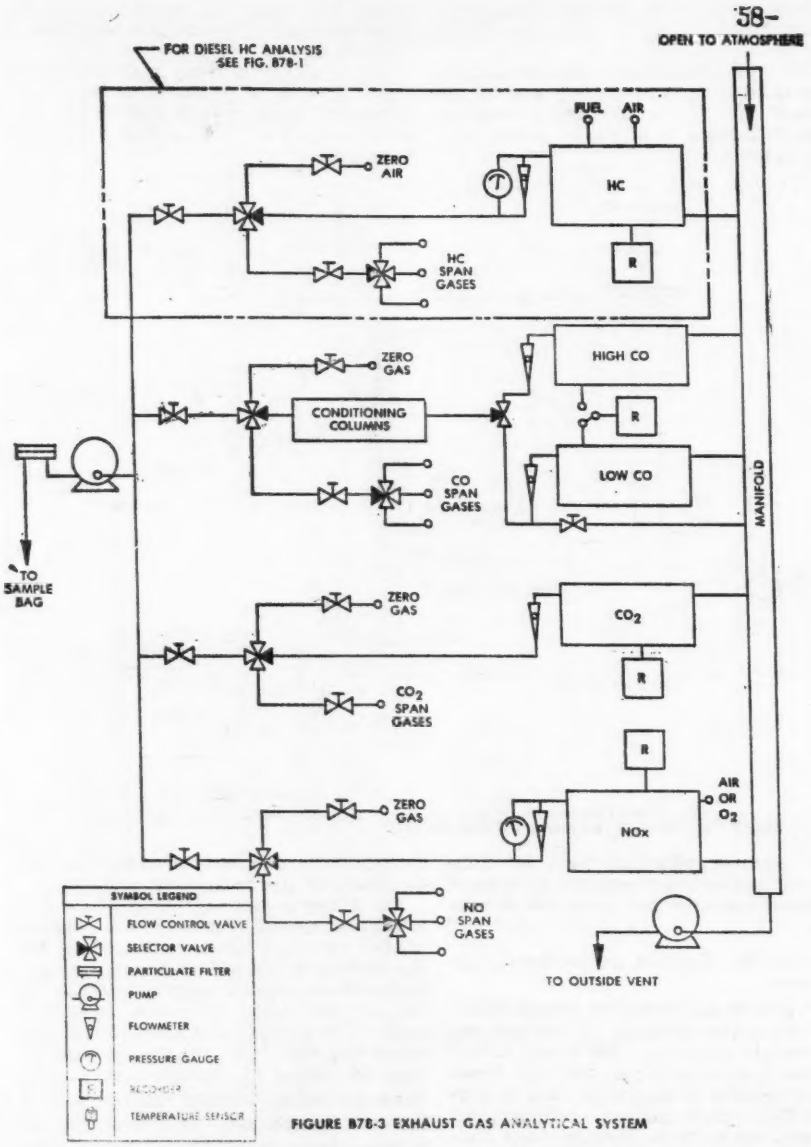


FIGURE B78-3 EXHAUST GAS ANALYTICAL SYSTEM

(1) The chemiluminescence analyzer requires that the nitrogen dioxide present in the sample be converted to nitric oxide before analysis. Other types of analyzers may be used if shown to yield equivalent results and if approved in advance by the Administrator.

(2) The carbon monoxide (NDIR) analyzer may require a sample conditioning column containing $CaSO_4$, or indicating silica gel to remove water vapor and containing ascarite to remove carbon dioxide from the CO analysis stream.

(i) If CO instruments which are essentially free of CO_2 and water vapor interference are used, the use of the conditioning column may be deleted, see § 86.119 and § 86.138.

(ii) A CO instrument will be considered to be essentially free of CO_2 and water vapor interference if its response to a mixture of 3 percent CO_2 in N_2 which has been bubbled through water at room temperature produces an equivalent CO response, as measured on the most sensitive CO range, which is less than 1 percent of full scale CO concentration on ranges above 300 ppm full scale or less than 3 ppm on ranges below 300 ppm full scale, see § 86.119.

(3) For diesel fueled vehicles a continuous sample shall be measured using a heated analyzer train as shown in Figure B78–1. The train shall include a heated continuous sampling line, a heated particulate filter and a heated hydrocarbon instrument (HFID) complete with heated pump, filter and flow control system.

(i) The response time of this instrument shall be less than 1.5 second for 90 percent of full-scale response.

(ii) Sample transport time from sampling point to inlet of instrument shall be less than 4 seconds.

(iii) The sample line and filter shall be heated to a set point ±10° F (±5.6° C)

between 300 and 390° F (149 and 199° C).

(c) *Other analyzers and equipment.* Other types of analyzers and equipment may be used if shown to yield equivalent results and if approved in advance by the Administrator.

§ 86.111–78 Fuel specifications.

(a) *Gasoline.*

(1) Gasoline having the following specifications will be used by the Administrator in exhaust and evaporative emission testing. Gasoline having the following specifications or substantially equivalent specifications approved by the Administrator, shall be used by the manufacturer in exhaust and evaporative testing, except that the lead and octane specifications do not apply.

Item designation	ASTM	Leaded	Unleaded
Octane, research, minimum	D2699	100	98
Pb. (organic), grams/U.S. gallon		[1] 1.4	0.00–0.05
Distillation range:			
IBP [2], (degrees Fahrenheit)	D86	75–95	75–95
10-pct point, (degrees Fahrenheit)	D86	120–135	120–135
50-pct point, (degrees Fahrenheit)	D86	200–230	200–230
90-pct point, (degrees Fahrenheit)	D86	300–325	300–325
EP, (degrees Fahrenheit) (maximum)	D86	415	415
Sulphur, weight percent, maximum	D1266	0.10	.10
Phosphorus, grams/U.S. gallon, maximum		.01	.005
RVP, [3, 4] pounds	D323	8.7–9.2	8.7–9.2
Hydrocarbon composition:			
Olefins, percent, maximum	D1319	10	10
Aeromatics, percent, maximum	D1319	35	35
Saturates	D1319	[5]	[5]

[1] Minimum.
[2] For testing at altitudes above 1,219 m (4,000 ft) the specified range is 75–105.
[3] For testing which is unrelated to evaporative emission control, the specified range is 8.0–9.2.
[4] For testing at altitudes above 1,219 m (4,000 ft) the specified range is 7.9–9.2.
[5] Remainder.

(2) Gasoline representative of commercial gasoline which will be generally available through retail outlets shall be used in service accumulation. For leaded gasoline the minimum lead content shall be 1.4 grams per U.S. gallon, except that where the Administrator determines that vehicles represented by a test vehicle will be operated using gasoline of different lead content than that prescribed in this paragraph, he may consent in writing to use of a gasoline with a different lead content. The octane rating of the gasoline used shall be no higher than 4.0 research octane numbers above the minimum recommended by the manufacturer. The Reid Vapor Pressure of the gasoline used shall be characteristic of the motor fuel used during the season in which the service accumulation takes place.

(3) The specification range of the gasoline to be used under paragraph (a)(2) of this section shall be reported in accordance with § 86.077–21(b)(3).

(b) *Diesel fuel.*

(1) The diesel fuels employed for testing shall be clean and bright, with pour and cloud points adequate for operability. The diesel fuel may contain nonmetallic additives as follows: Cetane improver, metal deactivator, antioxidant, dehazer, antirust, pour depressant, dye, and dispersant.

(2) Diesel fuel meeting the following specifications, or substantially equivalent specifications approved by the Administrator, shall be used in exhaust emissions testing. The grade of diesel fuel recommended by the engine manufacturer commercially designated as "Type 1–D" or "Type 2–D," shall be used.

Item	ASTM test method No:	Type 1–D	Type 2–D
Cetane	D613	48–54	45–50
Distillation range	D86		
IBP (degrees Fahrenheit)		330–390	340–400
10-pct point (degrees Fahrenheit)		370–430	400–460
50-pct point (degrees Fahrenheit)		410–480	470–540
90-pct point (degrees Fahrenheit)		460–520	550–610
EP (degrees Fahrenheit)		500–560	580–660
Gravity, degrees API	D287	40–44	33–37
Total sulfur, percent	D129 or D2622	0.05–0.20	0.2–0.5
Hydrocarbon composition	D1319		
Aromatics, percent		8–15	[2] 27
Paraffins, naphthenes, olefins		[1]	[1]
Flashpoint (degrees Fahrenheit) (minimum)	D93	120	130
Viscosity, centistokes	D445	1.6–2.0	2.0–3.2

[1] Remainder.
[2] Minimum.

(3) Diesel fuel meetng the following specifications, or substantially equvalent specificatons approved by the Adminstrator, shall be used in service accumulaton. The grade of diesel fuel recommended by the engine manufacturer, commercially designated as "Type I–D" or "Type 2–D," shall be used.

Item	ASTM test method No.	Type 1-D	Type 2-D
Cetane	D613	40–54	40–55
Distillation range			
IBP (degree Fahrenheit)		330–360	340–420
10-pct point, (degrees Fahrenheit)		370–420	400–470
50-pct point, (degrees Fahrenheit)		410–480	470–540
90-pct point, (degrees Fahrenheit)		460–520	550–610
EP (degrees Fahrenheit)		500–560	580–660
Gravity, degrees API	D287	40–44	32–40
Total sulfur, percent	D129 or D2622	0.05–0.20	0.2–0.5
Flashpoint, (degrees Fahrenheit) (minimum)	D93	120	130
Viscosity, centistokes	D445	1.6–2.0	2.0–3.2

(4) Other petroleum distillation fuel specifications:

(i) Other petroleum distillate fuels may be used for testing and service accumulation provided they are commercially available, and

(ii) Information, acceptable to the Administrator, is provided to show that only the designated fuel would be used in customer service, and

(iii) Use of a fuel listed under paragraphs (b)(2) and (b)(3) of this section would have a detrimental effect on emissions or durability, and

(iv) Written approval from the Administrator of the fuel specifications was provided prior to the start of testing.

(5) The specification range of the fuels to be used under paragraphs (b)(2), (b)(3), and (b)(4) of this section shall be reported in accordance with § 86.077–21(b)(3).

§ 86.112–78 Analytical gases.

(a) Analyzer gases.

(1) Gases for the CO and CO_2 analyzers shall be single blends of CO and Co_2 respectively using nitrogen as the diluent.

(2) Gases for the hydrocarbon analyzer shall be single blends of propane using air as the diluent.

(3) Gases for NOx analyzer shall be single blends of NO named as NOx with a maximum NO_2 concentration of 5 percent of the nominal value using nitrogen as the diluent.

(4) Fuel for the evaporative emission enclosure FID shall be a blend of 60 percent helium and 40 percent hydrogen containing less than 1 ppm equivalent carbon response.

(5) The allowable zero gas (air or nitrogen) impurity concentrations shall not exceed 1 ppm equivalent carbon response, 1 ppm carbon monoxide, 0.04 percent (400 ppm) carbon dioxide and 0.1 ppm nitric oxide.

(6) "Zero grade air" includes artificial "air" consisting of a blend of nitrogen and oxygen with oxygen concentrations between 18 and 21 mole percent.

(b) Calibration gases shall be traceable to within 1 percent of NBS gas standards, or EPA gas standards or other gas standards which have been approved by the Administrator.

(c) Span gases shall be accurate to within 2 percent of true concentration, where true concentration refers to NBS gas standards, EPA gas standards or other gas standards which have been approved by the Administrator.

§ 86.113–78 EPA Urban Dynamometer Driving Schedule.

(a) The dynamometer driving schedule is listed in Appendix I. The driving schedule is defined by a smooth trace drawn through the specified speed vs. time relationships. It consists of a nonrepetitive series of idle, acceleration, cruise, and deceleration modes of various time sequences and rates.

(b) The speed tolerance at any given time on the dynamometer driving schedule prescribed in Appendix I or as printed on a driver's aid chart approved by the Administrator, when conducted to meet the requirements of § 86.133 is defined by upper and lower limits. The upper limit is 2 mph (3.2 kph) higher than the highest point on the trace within 1 second of the given time. The lower limit is 2 mph (3.2 kph) lower than the lowest point on the trace within 1 second of the given time. Speed variations greater than the tolerances (such as may occur during gear changes) are acceptable provided they occur for less than 2 seconds on any occasion. Speeds lower than those prescribed are acceptable provided the vehicle is operated at maximum available power during such occurrences. When conducted to meet the requirements of § 86.128 the speed tolerance shall be as specified above, except that the upper and lower limits shall be 4 mph (6.4 kph).

(c) Figure B78–4 shows the range of acceptable speed tolerances for typical points. Figures B78–4(a) is typical of portions of the speed curve which are increasing or decreasing throughout the two second time interval. Figure B78–4(b) is typical of portions of the speed curve which include a maximum or minimum value.

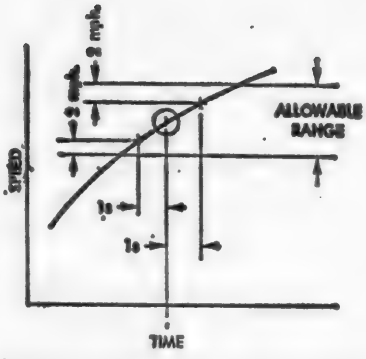


FIGURE B78-4a—DRIVERS TRACE, ALLOWABLE RANGE

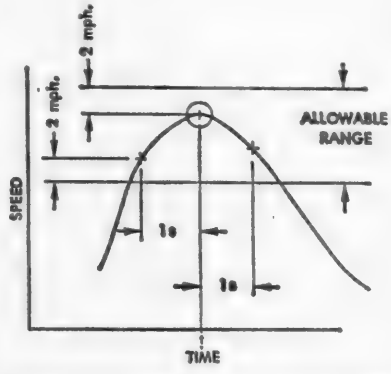


FIGURE B78-4b—DRIVERS TRACE, ALLOWABLE RANGE

§ 86.114–78 Calibrations, frequency and overview.

(a) Calibrations shall be performed as specified in §§ 86.115 through 86.122.

(b) At least yearly or after any maintenance, enclosure background emission measurements shall be performed.

(c) At least monthly or after any maintenance which could alter calibration, the following calibrations and checks shall be performed:

(1) Calibrate the hydrocarbon analyzers (both evaporative and exhaust instruments), carbon dioxide analyzer, carbon monoxide analyzer, oxides of nitrogen analyzer.

(2) Calibrate the dynamometer. If the dynamometer receives a weekly performance check (and remains within calibration) the monthly calibration need not be performed.

(3) Perform a hydrocarbon retention check and calibration on the evaporative emission enclosure.

(d) At least weekly or after any maintenance which could alter calibration,

the following calibrations and checks shall be performed:

(1) Check the oxides of nitrogen converter efficiency, and

(2) Perform a CVS system verification, and

(3) Run a performance check on the dynamometer. The check may be omitted if the dynamometer has been calibrated within the preceding month.

(e) The CVS positive displacement pump or Critical Flow Venturi shall be calibrated following initial installation, major maintenance or as necessary when indicated by the CVS system verification (described in § 86.117).

(f) Sample conditioning columns, if used in the CO analyzer train, should be checked at a frequency consistent with observed column life or when the indicator of the column packing begins to show deterioration.

§ 86.115–78 Evaporative emission enclosure calibrations.

The calibration of the evaporative emission enclosure consists of three parts: Initial and periodic determination of enclosure background emissions; initial determination of enclosure internal volume; and periodic hydrocarbon retention check and calibration.

(a) *Initial and periodic determination of enclosure background emissions.* Prior to its introduction into service, annually thereafter, and after repair, the enclosure shall be checked to determine that it does not contain materials which will themselves emit hydrocarbons.

Proceed as follows:

(1) Zero and span (calibrate if required) the hydrocarbon analyzer.

(2) Purge the enclosure until a stable background hydrocarbon reading is obtained.

(3) Turn on the mixing blower (if not already on).

(4) Seal enclosure and measure background hydrocarbon concentration, temperature and barometric pressure. These are the initial readings C_{HCi}, T_i and P_{Bi} for the enclosure background determination.

(5) Allow the enclosure to stand undisturbed without sampling for four hours.

(6) Measure the hydrocarbon concentration on the same FID. This is the final concentration, C_{HCf}. Also measure final temperature and barometric pressure.

(7) Calculate the mass change of hydrocarbons in the enclosure according to the equations in paragraph (d). The enclosure background emissions shall not be greater than 0.4g for the 4 hours.

(b) *Initial determination of enclosure internal volume.* Prior to its introduction into service the enclosure internal volume shall be determined by the following procedure.

(1) Carefully measure the internal length, width and height of the enclosure, accounting for irregularities (such as braces) and calculate the internal volume.

(2) Perform an enclosure calibration check according to paragraph (c) steps (1) through (7).

(3) If the calculated mass does not agree within 2% of the injected propane mass, then corrective action is required.

(c) *Hydrocarbon retention check and calibration.* The hydrocarbon retention check provides a check upon the calculated volume and also measures the leak rate. Prior to its introduction into service and at least monthly thereafter the enclosure leak rate shall be determined as follows:

(1) Zero and span (calibrate if required) the hydrocarbon analyzer.

(2) Purge the enclosure until a stable background hydrocarbon reading is obtained.

(3) Turn on the mixing blower (if not already on).

(4) Seal enclosure and measure background hydrocarbon cencentration, temperature and barometric pressure. These are the initial readings C_{HCi}, T_i and P_{Bi} for the enclosure calibration.

(5) Inject into the enclosure a measured of pure propane. The propane may be measured by volume flow or by mass measurement. The method used to measure the propane shall have an accuracy and precision of ±0.5% of the measured value.

(6) After a minimum of five minutes of mixing, analyze the enclosure atmosphere for hydrocarbon content, also record temperature and pressure. These measurements are the final readings for the enclosure calibration as well as the initial readings for the retention check.

(7) To verify the enclosure calibration calculate the mass of propane using the measurements taken in steps (4) and (6). See paragraph (d). This quantity must be within ±2% of that measured in step 5 above.

(8) Allow the enclosure to remain sealed for a minimum of four hours without sampling and with the mixing blower operating. After four hours analyze the enclosure atmosphere for hydrocarbon content; record temperature and barometric pressure. These are the final readings for the hydrocarbon retention check.

(9) Calculate, using the equations in paragraph (d) and the readings taken in (6) and (8), the hydrocarbon mass change. It must be less than ±0.4 g or the enclosure cannot be used.

(d) *Calculations.* The calculation of net hydrocarbon mass change is used to determine enclosure background and leak rate. It is also used to check the enclosure volume measurements. The mass change is calculated from the initial and final readings of hydrocarbon concentration, temperature and pressure according to the following equation:

$$M_{HC} = k\,V \times 10^{-4}\left[\frac{C_{HCf}P_{Bf}}{T_f} - \frac{C_{HCi}P_{Bi}}{T_i}\right]$$

Where:

M_{HC} = hydrocarbon mass change, g

C_{HC} = hydrocarbon concentration as ppm carbon

V = net enclosure volume, ft^3 (m^3), as measured in (b)(1) above

P_B = barometric pressure, in. Hg(kPa)

T = enclosure ambient temperature, R(K)

k = 3.05

for SI units, k = 17.60

i = indicates initial reading

f = indicates final reading

NOTE.—Hydrocarbon concentration is stated in ppm carbon, that is, ppm propane x3. Expressions in parenthesis are for SI units.

§ 86.116–78 Dynamometer calibration.

(a) The dynamometer shall be calibrated at least once each month or performance verified at least once each week and then calibrated as required. The calibration shall consist of the manufacturer's recommended calibration procedure plus a determination of the dynamometer frictional power absorption at 50.0 mph (80.5 kph). One method for determining dynamometer frictional power absorption at 50.0 mph (80.5 kph) is described below, other methods may be used if shown to yield equivalent results. The measured absorbed road power includes the dynamometer friction as well as the power absorbed by the power absorption unit. The dynamometer is driven above the test speed range. The device used to drive the dynamometer is then disengaged from the dynamometer and the roll(s) is (are) allowed to coast down. The kinetic energy of the system is dissipated by the dynamometer. This method neglects the variations in roll bearing friction due to the drive axle weight of the vehicle. The difference in coastdown time of the free (rear) roll relative to the drive (front) roll may be neglected in the case of dynamometers with paired rolls. These procedures shall be followed:

(1) Devise a method to determine the speed of the drive roll if it is not already measured. A fifth wheel, revolution pickup, or other suitable means may be used.

(2) Place a vehicle on the dynamometer or devise another method of driving the dynamometer.

(3) Engage the inertial flywheel or other inertial simulation system for the most common vehicle mass category for which the dynamometer is used.

(4) Drive the dynamometer up to 50.0 mph (80.5 kph).

(5) Record indicated road power.

(6) Drive the dynamometer up to 60.0 mph (96.9 kph).

(7) Disengage the device used to drive the dynamometer.

(8) Record the time for the dynamometer drive roll to coastdown from 55.0 mph (88.5 kph) to 45 mph (72.4 kph).

(9) Adjust the power absorption unit to a different level.

(10) Repeat steps 4 to 9 above sufficient times to cover the range of road power used.

(11) Calculate absorbed road power (HP_a). See paragraph (c).

(12) Plot indicated road load power at 50 mph (80.5 kph) versus road load power at 50 mph (80.5 kph) as shown in Figure B78–5.

(b) The performance check consists of conducting a dynamometer coast-down at one inertia-horsepower setting and comparing the coast-down time to that recorded during the last calibration. If

the coast-down times differ by more than 1 s, a new calibration is required.

(c) *Calculations.* The road load power actually absorbed by the dynamometer is calculated from the following equation:

$$HP_d = (1/2)\ (W/32.2)\ (V_1^2 - V_2^2)/550t$$

Where:

HP_d = Power, horsepower, (kilowatts)
W = Equivalent inertia, lb (Kg)
V_1 = Initial Velocity, ft/s (m/s)
(55 mph = 88.5 kph = 80.67 ft/s = 24.58 m/s)
V_2 = Final Velocity, ft/s (m/s)
(45 mph = 72.4 kph = 66 ft/s = 20.11 m/s)

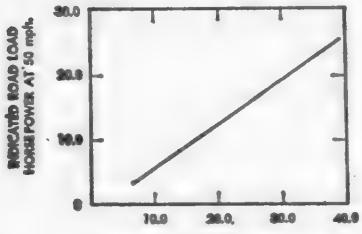


FIGURE B78-5 —ROAD LOAD HORSEPOWER, ACTUAL VS. INDICATED

t = elapsed time for rolls to coast from 55 mph to 45 mph (88.5 kph to 72.4 kph)

(Expressions in parenthesis are for SI units.) When the coast down is from 55 to 45 mph (88.5 to 72.4 kph) the above quotation reduces to:

$HP_d = 0.06073\ (W/t)$ for SI units,
$HP_d = 0.09984\ (W/t)$

§ 86.117–78 CVS calibration.

The CVS (Constant Volume Sampler) is calibrated using an accurate flowmeter and restrictor valve. Measurements of various parameters are made and related to flow through the unit. Procedures used by EPA for both PDP (Positive Displacement Pump) and CFV (Critical Flow Venturi) are outlined below. Other procedures yielding equivalent results may be used if approved in advance by the Administrator. After the calibration curve has been obtained, verification of the entire system can be performed by injecting a known mass of gas into the system and comparing the mass indicated by the system to the true mass injected. An indicated error does not necessarily mean that the calibration is wrong, since other factors can influence the accuracy of the system, e.g. analyzer calibration. A verification procedure is found in paragraph (c).

(a) PDP calibration.

(1) The following calibration procedure outlines the equipment, the test configuration, and the various parameters which must be measured to establish the flow rate of the constant volume sampler pump. All the parameters related to the pump are simultaneously measured with the parameters related to a flowmeter which is connected in series with the pump. The calculated flow rate ft^3/min. (at pump inlet absolute pressure and temperature) can then be plotted versus a correlation function which is the value of a specific combination of pump parameters. The linear equation which relates the pump flow and the correlation function is then determined. In the event that a CVS has a multiple speed drive, a calibration for each range used must be performed.

(2) This calibration procedure is based on the measurement of the absolute values of the pump and flowmeter parameters that relate the flow rate at each point. Three conditions must be maintained to assure the accuracy and integrity of the calibration curve. First, the pump pressures should be measured at taps on the pump rather than at the external piping on the pump inlet and outlet. Pressure taps that are mounted at the top center and bottom center of the pump drive headplate are exposed to the actual pump cavity pressures, and therefore reflect the absolute pressure differentials. Secondly, temperature stability must be maintained during the calibration. The laminar flowmeter is sensitive to inlet temperature oscillations which cause the data points to be scattered. Gradual changes (±2° F (1.1° C)) in temperature are acceptable as long as they occur over a period of several minutes. Finally, all connections between the flowmeter and the CVS pump must be absolutely void of any leakage.

(3) During an exhaust emission test the measurement of these same pump parameters enables the user to calculate the flow rate from the calibration equation.

(4) Connect a system as shown in Figure B78–6. Although particular types of equipment are shown, other configurations that yield equivalent results may be used if approved in advance by the Administrator. For the system indicated, the following data with given accuracy are required:

Calibration data measurements

Parameter	Symbol	Units	Tolerances
Barometric pressure (corrected)	P_B	in. Hg (kPa)	±.01 in. Hg (±.034 kPa).
Ambient temperature	T_A	°F (°C)	±.5°F (±.28°C).
Air temperature into LFE	ETI	°F (°C)	±.1°F (±.046°C).
Pressure depression upstream of LFE	EPI	in. H_2O (kPa)	±.05 in. H_2O (±.012 kPa).
Pressure drop across the LFE matrix	EDP	in. H_2O (kPa)	±.065 in. H_2O (±.001 kPa).
Air temperature at CVS pump inlet	PTI	°F (°C)	±.5°F (±.28°C).
Pressure depression at CVS pump inlet	PPI	in. fluid (kPa)	±.05 in Fluid (±.022 kPa).
Specific gravity of manometer fluid (1.75 oil)	Sp. Gr.		
Pressure head at CVS pump outlet	PPO	in. fluid (kPa)	±.05 in. Fluid (±.022 kPa).
Air temperature at CVS pump outlet (optional).	PTO	°F (°C)	±.5°F (±.28°C).
Pump revolutions during test period	N	Revs	
Elapsed time for test period	t	s	±.05 s.

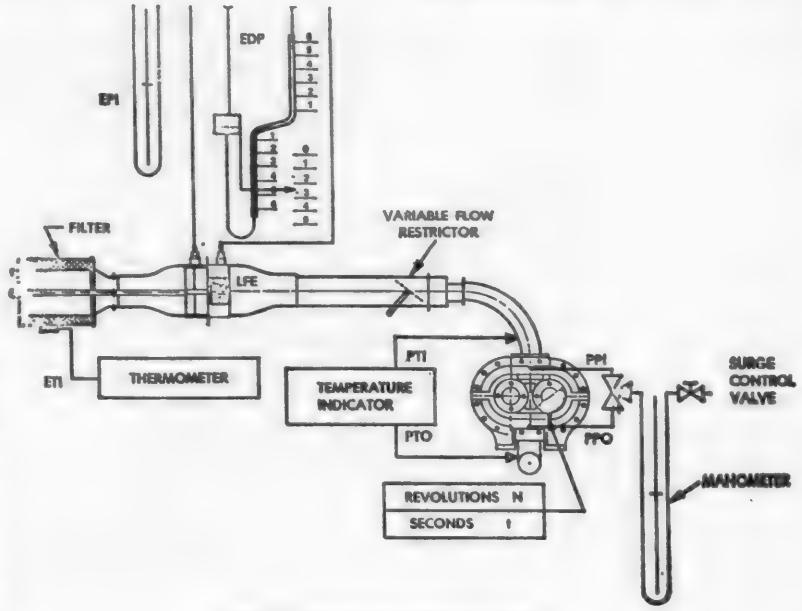
(5) After the system has been connected as shown in Figure B78–6, set the variable restrictor in the wide open position and run the CVS pump for twenty minutes. Record the calibration data.

(6) Reset the restrictor valve to a more restricted condition in an increment of pump inlet depression (about 4'' H_2O (1.0 kPa) that will yield a minimum of six data points for the total calibration. Allow the system to stabilize for 3 minutes and repeat the data acquisition.

(7) *Data analysis:*

(i) The air flow rate, Qs, at each test point is calculated in standard cubic feet per minute from the flowmeter data using the manufacturer's prescribed method.

(ii) The air flow rate is then converted to pump flow, V_o, in cubic feet per revolution at absolute pump inlet temperature and pressure.



B78-6 —PDP-CVS CALIBRATION CONFIGURATION

$$V_o = \frac{Q_s}{n} \times \frac{T_p}{528} \times \frac{29.92}{P_p}$$

Where:

V_o = Pump flow, ft^3/revolution (m^3/revolution) at T_p, P_p.

Q_s = Meter air flow rate in standard cubic feet per minute, standard conditions are 68° F, 29.29 in. Hg (20°C, 101.3 kPa).

n = Pump speed revolutions per minute.

T_p = Pump inlet temperature, °R(K) = PTI + 460

for SI units, T_p = PTI + 273

P_p = Absolute pump inlet pressure, in. Hg (kPa) = P_B − PPI (SP.GR./13.57)

for SI units, $P_p = P_B - PPI$

Where:

P_B = barometric pressure, in. Hg (kPa)

PPI = Pump inlet depression, in. fluid (kPa)

SP. GR. = Specific gravity of manometer fluid relative to water.

(iii) The correlation function at each test point is then calculated from the calibration data:

$$X_o = \frac{1}{n} \sqrt{\frac{\Delta P_p}{P_e}}$$

Where:

X_o = Correlation function.

ΔP_p = The pressure differential from pump inlet to pump outlet, in. Hg (kPa).

$= P_e - P_p$

P_e = Absolute pump outlet pressure, in. Hg (kPa) = $P_B + PPO$ (Sp. Gr./13.57)

for SI units, $P_e = P_B + PPO$

Where:

PPO = Pressure head at pump outlet, in. fluid (kPa)

(iv) A linear least squares fit is performed to generate the calibration equations which have the forms:

$$V_o = D_o - M(X_o)$$

$$n = A - B(\Delta P_p)$$

D_o, M, A, and B are the slope-intercept constants describing the lines.

(8) A CVS system that has multiple speeds should be calibrated on each speed used. The calibration curves generated for the ranges will be approximately parallel and the intercept values, D_o, will increase as the pump flow range decreases.

(9) If the calibration has been performed carefully, the calculated values from the equation will be within ±0.50% of the measured value of V_o. Values of M will vary from one pump to another, but values of D_o for pumps of the same make, model, and range should agree within ±3% of each other. Particulate influx from use will cause the pump slip to decrease as reflected by lower values for M. Calibrations should be performed at pump start-up and after major maintenance to assure the stability of the pump slip rate. Analysis of mass injection data will also reflect pump slip stability.

(b) *CFV calibration.*

(1) Calibration of the Critical Flow Venturi (CFV) is based upon the flow equation for a critical venturi. Gas flow is a function of inlet pressure and temperature:

$$Q_s = \frac{K_v P}{\sqrt{T}}$$

Where:

Q_s = Flow

K_v = Calibration coefficient

P = Absolute pressure

T = Absolute temperature

The calibration procedure described below establishes the value of the calibration coefficient at measured values of pressure, temperature and air flow.

(2) The manufacturer's recommended procedure shall be followed for calibrating electronic portions of the CFV.

(3) Measurements necessary for flow calibration are as follows:

Calibration data measurements

Parameter	Symbol	Units	Tolerances
Barometric Pressure (corrected)	P_B	in. Hg (kPa)	±.01 in. Hg (±.034 kPa).
Air temperature, flowmeter	ETI	°F (°C)	±.1° F (±.056°C).
Pressure depression upstream of LFE	EPI	in. H_2O (kPa)	±.05. in H_2O (±.012 kPa).
Pressure drop across LFE matrix	EDP	in. H_2O (kPa)	±.005 in. H_2O (±.001 kPa).
Air flow	Q_s	ft/min. (m/min.)	±.5%.
CFV inlet depression	PPI	in. fluid (kPa)	±.05 in. fluid (±.022 kPa).
Temperature at venturi inlet	T_v	°F (°C)	±.5° F (±.28°C).
Specific gravity of manometer fluid (1.75 oil).	Sp. Gr.		

(4) Set up equipment as shown in Figure B78–7 and check for leaks. Any leaks between the flow measuring device and the critical flow venturi will seriously affect the accuracy of the calibration.

(5) Set the variable flow restrictor to the open position, start the blower and allow the system to stabilize. Record data from all instruments.

(6) Vary the flow restrictor and make at least 8 readings across the critical flow range of the venturi.

(7) *Data analysis.* The data recorded during the calibration are to be used in the following calculations:

(i) The air flow rate, Q_s, at each test point is calculated in standard cubic feet per minute from the flow meter data using the manufacturer's prescribed method.

(ii) Calculate values of the calibration coefficient for each test point:

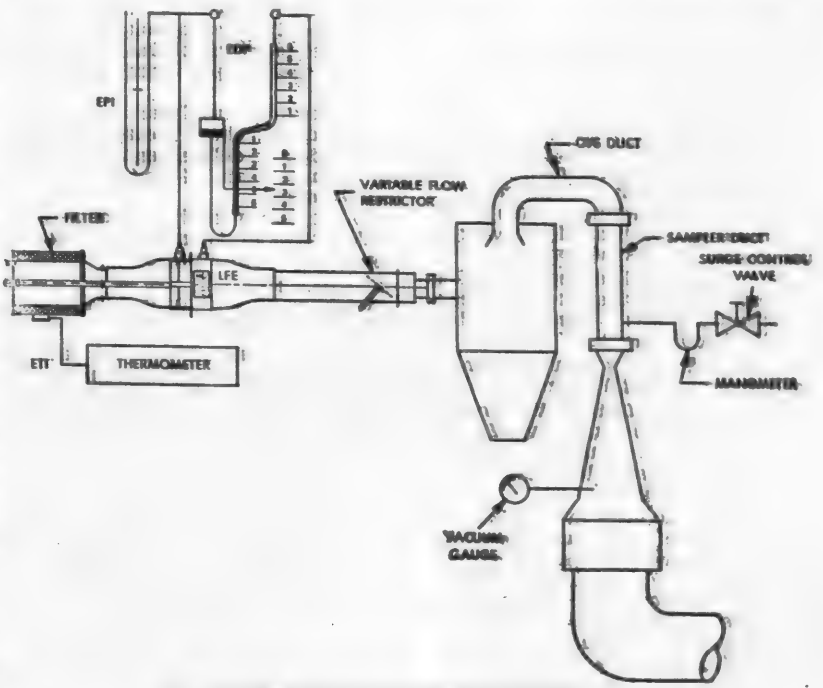


FIGURE B78-7 CFV-CVS CALIBRATION CONFIGURATION

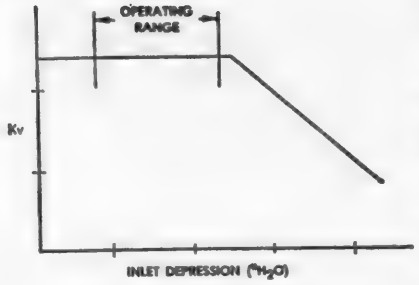


FIGURE B78-8—SONIC FLOW CHOKING

$$K_v = \frac{Q_s\sqrt{T_v}}{P_v}$$

Where:
Q_s = Flow rate in standard cubic feet per minute, standard conditions are 68° F, 29.92 in. Hg (20° C, 101.3 kPa).
T_v = Temperature at venturi inlet, R(K).
P_v = Pressure at venturi inlet, mm Hg (kPa) $= P_B - PPI$ (Sp. Gr./13.57).
for SI units $P_v = P_B - PPI$

Where:
PPI = Venturi inlet pressure depression, in. fluid (kPa).
Sp. Gr. = Specific gravity of manometer fluid, relative to water.

(iii) Plot K_v as a function of venturi inlet pressure. For sonic flow K_v will have a relatively constant value. As pressure decreases (vacuum increases) the venturi becomes unchocked and K_v decreases. See Figure B78–8.

(iv) For a minimum of 8 points in the critical region calculate an average K_v and the standard deviation.

(v) If the standard deviation exceeds 0.3% of the average K_v take corrective action.

(c) *CVS System Verification.* The following "gravimetric" technique can be used to verify that the CVS and analytical instruments can accurately measure a mass of gas that has been injected into the system. (Verification can also be accomplished by constant flow metering using critical flow orifice devices.)

(1) Obtain a small cylinder that has been charged with pure propane or carbon monoxide gas (caution—carbon monoxide is poisonous).

(2) Determine a reference cylinder weight to the nearest 0.01 grams.

(3) Operate the CVS in the normal manner and release a quantity of pure propane or carbon monoxide into the system during the sampling period (approximately 5 minutes).

(4) The calculations of § 86.138 are performed in the normal way except, in the case of propane. The density of propane (17.30 g/ft³/carbon atom (0.6109 kg/m³/carbon (atom)) is used in place of the density of exhaust hydrocarbons. In the case of carbon monoxide, the density of 32.97 g/ft³ (1.164 kg/m³) is used.

(5) The gravimetric mass is subtracted from the CVS measured mass and then divided by the gravimetric mass to determine the percent accuracy of the system.

(6) The cause for any discrepancy greater than ±2% must be found and corrected.

§ 86.118–78 Hydrocarbon analyzer calibration.

The FID hydrocarbon analyzer shall receive the following initial and periodic calibration (The HFID shall be operated to a set point ±10° F (± 5.5° C) between 300 and 390° F (149 and 199° C).

(a) Initial and periodic optimization of detector response. Prior to its introduction into service and annually thereafter the FID hydrocarbon analyzer shall be adjusted for optimum hydrocarbon response:

(1) Follow the manufacturer's instructions for instrument startup and basic operating adjustment using the appropriate fuel and zero grade air.

(2) Optimize on the most common operating range. Introduce into the analyzer, a propane in air mixture with a propane concentration equal to approximately 90% of the most common operating range.

(3) Select an operating fuel flow rate that will give near maximum response and least variation in response with minor fuel flow variations.

(4) To determine the optimum air flow, use the fuel flow setting determined above and vary air flow.

(5) After the optimum flow rates have been determined, they are recorded for future reference.

(b) Initial and periodic determination of oxygen effect. Prior to its introduction into service and at least annually thereafter the FID hydrocarbon analyzer shall be checked to determine the effect of oxygen in the sample upon instrument response:

(1) Zero the analyzer on nitrogen (N_2) zero gas; check the zero by using zero grade air; differences in zero reading of more than 2% will require corrective action.

(2) The following blends of propane shall be used to determine the effect of oxygen (O_2) in the sample.

Propane in N_2
Propane in 9.5 to 10.5% O_2, balance N_2
Propane in zero grade air

The volume concentration of propane in the mixtures should be equal to approximately 90% of the most common operating range. The zero shall be checked after each mixture is measured. If the zero has changed, the measurement shall be repeated.

(3) If the response to propane in air differs by more than 3% from the response to propane in the 10% O_2/90% N_2 mixture, or differs by more than 5% from the response to propane in N_2 corrective action will be required.

(4) If the response to propane in N_2 differs by more than 2% from the response to propane in 10% O_2/90% N_2 corrective action will be required.

(c) Initial and periodic calibration. Prior to its introduction into service and monthly thereafter the FID hydrocarbon analyzer shall be calibrated on all normally used instrument ranges. Use the same flow rate as when analyzing samples.

(1) Adjust analyzer to optimize performance.

(2) Zero the hydrocarbon analyzer with zero grade air.

(3) Calibrate on each normally used operating range with propane in air calibration gases having nominal concentrations of 50 and 100% of that range.

§ 86119–78 Carbon monoxide analyzer calibration.

The NDIR carbon monoxide analyzer shall receive the following initial and periodic calibrations:

(a) Initial and periodic interference check. Prior to its introduction into service and annually thereafter the NDIR carbon monoxide analyzer shall be checked for response to water vapor and CO_2:

(1) Follow the manufacturer's instructions for instrument startup and operation. Adjust the analyzer to optimize performance on the most sensitive range.

(2) Zero the carbon monoxide analyzer with either zero grade air or zero grade nitrogen.

(3) Bubble a mixture of 3% CO_2 in N_2 through water at room temperature and record analyzer response.

(4) An analyzer response of more than 1% of ful scale for ranges above 300 ppm full scale or of more thna 3 ppm on ranges below 300 ppm full scale will require correction action. (Use of conditioning columns is one form of corrective action which may be taken.)

(b) Initial and periodic calibration. Prior to its introduction into service and monthly thereafter the NDIR carbon monoxide analyzer shall be calibrated.

(1) Adjust the analyzer to optimize performance.

(2) Zero the carbon monoxide analyzer with either zero grade air or zero grade nitrogen.

(3) Calibrate on each normally used operating range with carbon monoxide in N_2 calibration gases having nominal concentrations of 15, 30, 45, 60, 75, and 90% of that range. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2% or less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds 2% at any point, the best-fit non-linear equation which represents the data to within 2% of each test point shall be used to determine concentration.

§ 86.120–78 Oxides of nitrogen analyzer calibration.

The chemiluminescent oxides of nitrogen analyzer shall receive the following initial and periodic calibration.

(a) Prior to its introduction into service and weekly thereafter the chemiluminescent oxides of nitrogen analyzer shall be checked for NO_2 to NO converter efficiency. Figure B78–9 is a reference for the following steps:

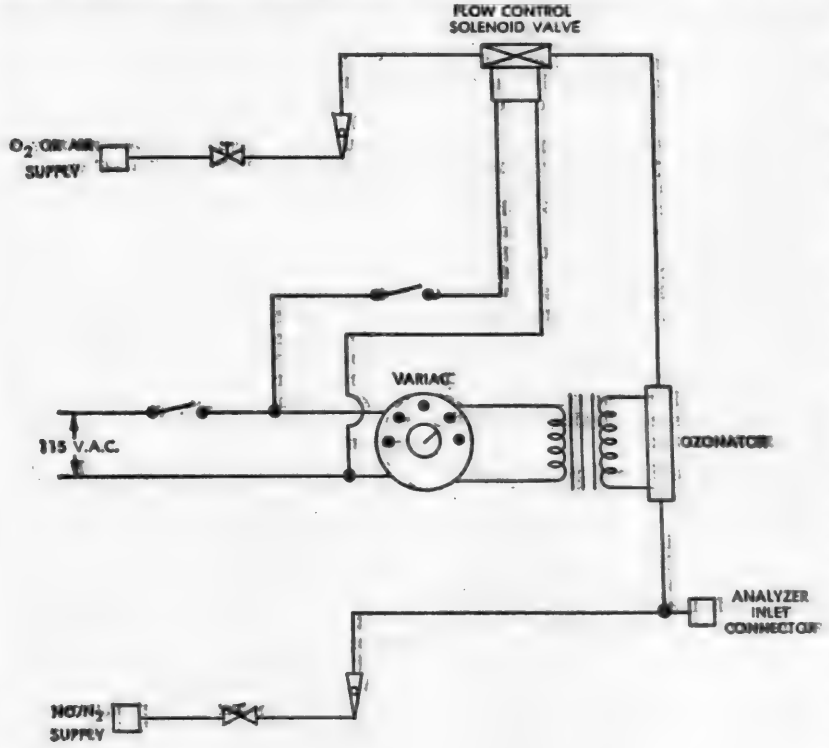
(1) Follow the manufacturer's instructions for instrument startup and

operation. Adjust the analyzer to optimize performance.

(2) Zero the oxides of nitrogen analyzer with zero grade air or zero grade nitrogen.

(3) Connect the outlet of the NOx generator to the sample inlet of the oxides of nitrogen analyzer which has been set to the most common operating range.

(4) Introduce into the NOx generator analyzer system an NO in nitrogen (N_2) mixture with a NO concentration equal to approximately 80% of the most common operating range. The NO_2 content of the gas mixture shall be less than 5% of the NO concentration.



(SEE FIG. 878-2 FOR SYMBOL LEGEND)
FIGURE 878-9 —NOx CONVERTER EFFICIENCY DETECTOR

(5) With the oxides of nitrogen analyzer in the NO mode, record the concentration of NO indicated by the analyzer.

(6) Turn on the NOx generator O_2 (or air) supply and adjust the O_2 (or air) flow rates so that the NO indicated by the analyzer is about 10% less than indicated in step 5. Record the concentration of NO in this NO + O_2 mixture.

(7) Switch the NOx generator to the generation mode and adjust the generation rate so that the NO measured on the analyzer is 20% of that measured in step 5. There must be at least 10% unreacted NO at this point. Record the concentration of residual NO.

(8) Switch the oxides of nitrogen analyzer to the NOx mode and measure total NOx. Record this value.

(9) Switch off the NOx generation but maintain gas flow through the system. The oxides of nitrogen analyzer will indicate the NOx in the NO+O_2 mixture. Record this value.

(10) Turn off the NOx generator O_2 (or air) supply. The analyzer will now indicate the NOx in the original NO in N_2 mixture. This value should be no more than 5% above the value indicated in step 4.

(11) Calculate the efficiency of the NOx converter by substituting the concentrations obtained into the following equation:

$$\% \text{ Eff.} = \left(1 + \frac{a-b}{c-d}\right) \times 100$$

where

a = concentration obtained in step 8
b = concentration obtained in step 9
c = concentration obtained in step 6
d = concentration obtained in step 7

If converter efficiency is not greater than 90% corrective action will be required.

(b) Initial and periodic calibration. Prior to its introduction into service and monthly thereafter the chemiluminescent oxides of nitrogen analyzer shall be calibrated on all normally used instrument ranges. Use the same flow rate as when analyzing samples. Proceed as follows:

(1) Adjust analyzer to optimize performance.

(2) Zero the oxides of nitrogen analyzer with zero grade air or zero grade nitrogen.

(3) Calibrate on each normally used operating range with NO in N_2 calibration gases with nominal concentrations of 50 and 100% of that range.

§ 86.121–78 Carbon dioxide analyzer calibration.

Prior to its introduction into service and monthly thereafter the NDIR carbon dioxide analyzer shall be calibrated:

(a) Follow the manufacturer's instructions for instrument startup and operation. Adjust the analyzer to optimize performance.

(b) Zero the carbon dioxide analyzer with either zero grade air or zero grade nitrogen.

(c) Calibrate on each normally used operating range with carbon dioxide in N_2 calibration gases with nominal concentrations of 15, 30, 45, 60, 75, and 90% of that range. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2% or less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds 2% at any point, the best-fit non-linear equation which represents the data to within 2% of each test point shall be used to determine concentration.

§ 86.122–78 Calibration of other equipment.

Other test equipment used for testing shall be calibrated as often as required by the manufacturer or as necessary according to good practice.

§ 86.123–78 Test procedures, overview.

The procedures described in this and subsequent sections are used to determine the conformity of vehicles with the standards set forth in Subpart A for light duty vehicles and light duty trucks.

(a) The overall test consists of prescribed sequences of fueling, parking and operating conditions. Vehicles are either tested for only exhaust emissions or are tested for exhaust and evaporative emissions. The evaporative portion of the test procedure occurs before and after the exhaust emission test, and, in some cases, during the exhaust emission test.

(b) The exhaust emission test is designed to determine hydrocarbon, carbon monoxide, and oxides of nitrogen mass emissions while simulating an average trip in an urban area of 7.5 miles (12.1 km). The test consists of engine startups and vehicle operation on a chassis dynamometer, through a specified driving schedule. A proportional part of the diluted exhaust emissions is collected continuously for subsequent analysis, using a constant volume (variable dilution) sampler. (Diesel dilute exhaust is continuously analyzed for hydrocarbons using a heated sample line and analyzer).

(c) The evaporative emission test (gasoline fueled vehicles only) is designed to determine hydrocarbon evaporative

emissions as a consequence of diurnal temperature fluctuation, urban driving, and hot soaks during parking. It is associated with a series of events representative of a motor vehicle's operation, which result in hydrocarbon vapor losses. The test procedure is designed to measure:

(1) Diurnal breathing losses resulting from daily temperature changes, measured by the enclosure technique;

(2) Running losses from suspected sources (if indicated by engineering analysis or vehicle inspection) resulting from a simulated trip on a chassis dynamometer, measured by carbon traps; and

(3) Hot soak losses which result when the vehicle is parked and the hot engine is turned off, measured by the enclosure technique.

(d) Except in cases of component malfunction or failure, all emission control systems installed on or incorporated in a new motor vehicle shall be functioning during all procedures in this subpart. Maintenance to correct component malfunction or failure shall be authorized in accordance with § 86.077.

§ 86.124–78 Transmissions.

(a) All test conditions shall be run with automatic and automatic stick shift transmissions in "Drive" (highest gear); manual transmissions shall be run in highest gear, except as noted. Automatic stick-shift transmissions may be shifted as manual transmissions if requested by the manufacturer.

(b) Cars equipped with free-wheeling or overdrive units shall be tested with these units locked out of operation.

(c) Idle modes shall be run with automatic transmissions in "Drive" and the wheels braked, manual transmissions shall be in gear with the clutch disengaged; except first idle, see §§ 86.132 and 86.133.

(d) The vehicle shall be driven with minimum accelerator pedal movement to maintain the desired speed.

(e) Acceleration modes shall be driven smoothly. Automatic transmissions shall shift automatically through the normal sequence of gears; manual transmissions shall be shifted as recommended by the manufacturer with the operator releasing the accelerator pedal during each shift and accomplishing the shift with minimum time. If the vehicle cannot accelerate at the specified rate, the vehicle shall be operated with the accelerator pedal fully depressed until the vehicle speed reaches the value prescribed for that time in the driving schedule.

(f) The deceleration modes shall be run in gear using brakes or accelerator pedal as necessary to maintain the desired speed. Manual transmission vehicles shall have the clutch engaged and shall not change gears from the previous mode. For those modes which decelerate to zero, manual transmission clutches shall be depressed when the speed drops below 15 mph (24.14 kph), when engine roughness is evident, or when engine stalling is imminent.

(g) Manual transmissions will be down shifted at the beginning of or during a power mode if recommended by the manufacturer or if the engine obviously is lugging.

(h) If shift speeds are not recommended by the manufacturer, manual transmission vehicles shall be shifted from first to second gear at 15 mph (24.14 kph), from second to third gear at 25 mph (40.23 kph), and, if so equipped, from third to fourth gear at 40 mph (64.37 kph). Fifth gear, if so equipped, may be used at the manufacturer's option.

(i) If a four- or five-speed manual transmission has a first gear ratio in excess of 5:1, follow the procedure for three- or four-speed vehicles as if the first gear did not exist.

§ 86.125–78 Road load power and inertia weight determination.

(a) Flywheels, electrical or other means of simulating intertia as shown in the following table shall be used. If the equivalent inertia specified is not available on the dynamometer being used, the next higher equivalent inertia (not to exceed 250 lbs) available shall be used.

Loaded vehicle weight (pounds)	Equivalent inertia weight (pounds)	Road load power at 50 mph (horsepower)
Up to 1,125	1,000	5.9
1,126 to 1,375	1,250	6.5
1,376 to 1,625	1,500	7.1
1,626 to 1,875	1,750	7.7
1,876 to 2,125	2,000	8.3
2,126 to 2,375	2,250	8.8
2,376 to 2,625	2,500	9.4
2,626 to 2,875	2,750	9.9
2,876 to 3,250	3,000	10.3
3,251 to 3,750	3,500	11.2
3,751 to 4,250	4,000	12.0
4,251 to 4,750	4,500	12.7
4,751 to 5,250	5,000	13.4
5,251 to 5,750	5,500	13.9
5,751 to above	5,500	14.4

(b) Power absorption unit adjustment.

(1) The power absorption unit shall be adjusted to reproduce road load power at 50 mph true speed. The indicated road load power setting shall take into account the dynamometer friction. The relationship between road load (absorbed) power and indicated road load power for a particular dynamometer shall be determined by the procedure outlined in § 86.116 or other suitable means.

(2) The road load power listed in the table above shall be used or the vehicle manufacturer may determine the road load power by an alternative procedure requested by the manufacturer and approved in advance by the Administrator, or the vehicle manufacturer may determine the road load power by the following procedure and request its use:

(i) Gasoline fueled vehicles.

(A) Measuring the absolute manifold pressure of a representative vehicle, of the same equivalent inertia weight class, when operated on a level road under balanced wind conditions at a true speed of 50 mph (80 kph), and

(B) Noting the dynamometer indicated road load horsepower setting required to reproduce that manifold pressure when the same vehicle is operated on the dynamometer at a true speed of 50 mph. The tests on the road and on the dynamometer shall be performed with the same vehicle ambient absolute pressure (usually barometric), i.e., within ±5 mm Hg (±0.7 kPa).

(C) The road load power shall be determined according to the procedure outlined in § 86.116 and adjusted according to the following if applicable.

(ii) Diesel vehicles.

(A) Measuring the fuel flow rate of a representative vehicle of the same equivalent inertia weight class, when operated on a level road under balanced wind conditions at a true speed of 50 mph, and

(B) Noting the dynamometer indicated road load horsepower setting required to reproduce that fuel flow rate when the same vehicle is operated on the dynamometer at a true speed of 50 mph (80 kph). The tests on the road and on the dynamometer shall be performed with the same vehicle ambient absolute pressure (usually barometric), i.e. within ±5 mm Hg (±0.7 kPa).

(C) The road load power shall be determined according to the procedure outlined in § 86.116 and adjusted according to the following if applicable.

(3) Where it is expected that more than 33 percent of the vehicles in an engine family will be equipped with air conditioning, the road load power listed above or as determined in paragraph (b)(2) of this section shall be increased by 10 percent for testing all test vehicles representing such engine family if those vehicles are intended to be offered with air conditioning in production.

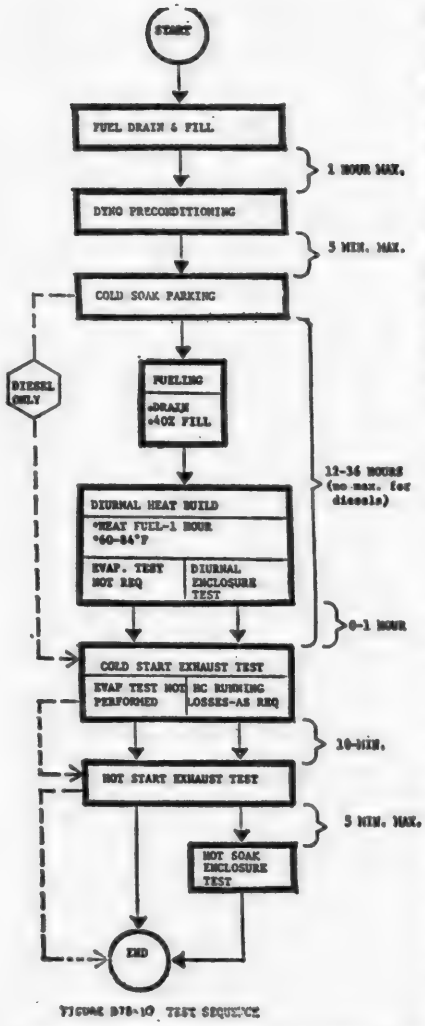


FIGURE B78-10. TEST SEQUENCE

§ 86.126–78 Test sequence, general requirements.

The test sequence shown in Figure B78–10 shows the steps encountered as the test vehicle undergoes the procedures subsequently described to determine conformity with the standards set forth. Ambient temperature levels encountered by the test vehicle throughout the test sequence shall not be less than 68° F (20° C) nor more than 86° F (30° C.) The vehicle shall be approximately level during all phases of the test sequence to prevent abnormal fuel distribution.

§ 86.127–78 Vehicle preparation.

(a) For gasoline fueled vehicles prepare the fuel tank(s) for recording the temperature of the prescribed test fuel at the approximate mid volume of the fuel.

(b) Provide additional fittings and adapters, as required, to accommodate a fuel drain at the lowest point possible in the tank(s) as installed on the vehicle.

§ 86.128–78 Vehicle preconditioning.

(a) The vehicle shall be moved to the test area and the following operations performed:

(1) The fuel tank(s) shall be drained through the provided fueled tank(s) drain(s) and filled in the normal fashion to contain approximately 2 gallons (7.57 liters) of the specified test fuel, § 86.111 (for diesel powered vehicles the tank shall be filled to the prescribed "tank fuel volume", defined in § 86.078–2). When additional preconditioning, as described in (a)(3) is to be performed, additional fuel may be added up to the prescribed "tank fuel volume". For the above operations the evaporative emission control system shall neither be abnormally purged nor abnormally loaded.

(2) Within one hour of being fueled the vehicle shall be place, either by being driven or pushed, on a dynamometer and operated through one Urban Dynomometer Driving Schedule test procedure, see § 86.113 and Appendix I. A gasoline fueled test vehicle may not be used to set dynamometer horsepower.

(3) For those unusual circumstances where additional preconditioning is desired by the manufacturer, such preconditioning may be allowed with the advance approval of the Administrator. The Administrator may also choose to conduct or require the conduct of additional preconditioning to insure that the evaporative emission control system is stabilized. The additional preconditioning shall consist of an initial one hour minimum soak and, one, two or three driving cycles of the UDDS, as described in (a)(2), each followed by a soak of at least one hour with engine off, engine compartment cover closed and cooling fan off. The vehicle may be driven off the dynamometer following each UDDS for the soak period.

(b) Within five minutes of completion of preconditioning the vehicle shall be driven off the dynamometer and parked. The vehicle shall be stored for not less than 12 hours nor for more than 36 hours (except diesel fueled vehicles which have no maximum time limitation) prior to the cold start exhaust test. (Gasoline fueled vehicles undergo a one hour diurnal heat build prior to the cold start exhaust test. A wait of up to one hour is permitted between the end of the diurnal heat build and the beginning of the cold start exhaust test. See § 86.126 and Figure B78–10.)

(c) Vehicles to be tested for evaporative emissions shall be processed in accordance with procedures in §§ 86.129 through 86.134. Vehicles to be tested for exhaust emissions only shall be processed according to §§ 86.129 through 86.133.

§ 86.129–78 Diurnal breathing loss test.

(a)(1) Following vehicle preparation and vehicle preconditioning procedures described in § 86.127 and § 86.128 the test vehicle shall be allowed to soak for a period of not less than 12 hours or more than 36 hours prior to the exhaust emission test. The diurnal test shall take place not less than 10 or more than 35 hours after the end of the preconditioning procedure. The start of the exhaust test shall follow the end of the diurnal test within one hour.

(2) Gasoline fueled vehicles to be tested for exhaust emissions only, shall undergo the diurnal heat build. Since no evaporative measurements are necessary, an evaporative enclosure is not required.

(b) The evaporative emission enclosure shall be purged for several minutes immediately prior to the test.

NOTE.—If at any time the hydrocarbon concentration exceed 15,000 ppm C the enclosure should be immediately purged. This concentration provides a 4:1 safety factor against the lean flammability limit.

(c) The FID hydrocarbon analyzer shall be zeroed and spanned immediately prior to the test.

(d) If not already on, the evaporative enclosure mixing fan shall be turned on at this time.

(e) Immediately prior to the diurnal breathing loss test, the fuel tank(s) of the prepared vehicle shall be drained and recharged with the specified test fuel, § 86.111, to the prescribed "tank fuel volume," definied in § 86.078–2. The temperature of the fuel prior to its delivery to the fuel tank shall be between 50 and 60° F (10 and 16° C).

(f) The test vehicle, with the engine shut off, shall be moved into the evaporative emission enclosure, the test vehicle windows and luggage compartments shall be opened, the fuel tank temperature sensor shall be connected to the temperature recording system, and, if required, the heat source shall be properly positioned with respect to the fuel tank(s) and/or connected to the temperature controller.

(g) The enclosure doors shall be closed and sealed.

(h) The temperature recording system shall be started.

(i) When the fuel temperature recording system reaches 60±1° F (16±0.5° C), immediately:

(1) Analyze enclosure atmosphere for hydrocarbons and record. This is the initial (time=0 minutes) hydrocarbon concentration, C_{HC_i}, § 86.137.

(2) Start diurnal heat build and record time. This commences the 60±2 minute test period.

(j) The fuel shall be heated in such a way that its temperature change conforms to the following function to within ±2° F (±1.1° C):

$F = 60 + 0.4t$

for SI units, $C = 15.556 + (2/9)t$

Where:

F=fuel temperature, °F

C=fuel temperature, °C

t=time since beginning of test, minutes.

After 60±2 minutes of heating, the fuel temperature shall be 84±1° F (29±0.5° C).

(k) The FID hydrocarbon analyzer shall be zeroed and spanned immediately prior to the end of the diurnal test.

(l) The end of the diurnal breathing loss test occcurs 60±2 minutes after the heat build begins, subparagraph (l)(2). Analyze the enclosure atmosphere for hydrocarbons and record. This is the final (time=60 minutes) hydrocarbon concentration, C_{HFi}, § 86.137. The time (or elapsed time) of this analysis shall be recorded.

(m) The heat source shall be turned off and and the enclosure doors unsealed and opened.

(n) The heat source shall be moved away from the vehicle, if required, and/or disconnected from the temperature controller, the fuel tank temperature sensor shall be disconnected from the temperatude recording system, the test vehicle windows and luggage compartments may be closed and the test vehicle, with the engine shut off, shall be removed from the evaporative emission enclosure.

§ 86.130–78 Running loss test.

(a) If an engineering analysis or vehicle inspection indicates the possibility of evaporative emissions during vehicle operation, evaporative emission running loss measurements shall be made during the cold transient and stabilized portion of the exhaust emission test. Since running loss measurements cannot be made in the enclosure, the equipment described in § 86.177–17 shall be used to collect these emissions.

(1) The procedure in § 86.131 shall be followed.

(2) Prior to the initiation of the cold start exhaust emission test, the vapor loss measurement system shall be connected to all suspected sources of running loss evaporative emissions.

(3) The cold start transient and stabilized exhaust emission test portions shall be conducted according to the procedures of § 86.131 through § 86.133.

(4) Within one minute after the end of the stabilized exhaust emission test, the vapor loss measurement system shall be disconnected from the vehicle and the inlets and outlets sealed.

(5) Within one hour from the end of the running loss measurement, weigh the vapor collection traps.

§ 86.131–78 Dynamometer procedure.

(a) The dynamometer run consists of two tests, a "cold" start test after a minimum 12-hour and a maximum 36 hour soak according to the provisions of § 86.128 and § 86.129 and a "hot" start test following the "cold" start by 10 minutes. Engine startup (with all accessories turned off), operation over the driving schedule, and engine shutdown make a complete cold start test. Engine startup and operation over the first 505 seconds of the driving schedule complete the hot start test. The exhaust emissions are diluted with ambient air and a continuously proportional sample is collected for analysis during each phase. The composite samples collected in bags are analyzed for hydrocarbons (except diesel hydrocarbons which are analyzed continuously), carbon monoxide, carbon dioxide, and oxides of nitrogen. A parallel sample of the dilution air is similarly analyzed for hydrocarbon, carbon monoxide, and oxides of nitrogen.

(b) During dynamometer operation, a fixed speed cooling fan shall be positioned so as to direct cooling air to the vehicle in an appropriate manner with the engine compartment cover open. In the case of vehicles with front engine compartments, the fan shall be squarely positioned within 12 inches of the vehicle. In the case of vehicles with rear engine compartments (or if special designs make the above impractical), the cooling fan shall be placed in a position to provide sufficient air to maintain vehicle cooling. The fan capacity shall normally not exceed 5,300 cfm (2.50 m^3/s). If, however, the manufacturer can show that during field operation the vehicle receives additional cooling, and that such additional cooling is needed to provide a representative test, the fan capacity may be increased or additional fans used if approved in advance by the Administrator.

(c) The vehicle speed as measured from the dynamometer rolls shall be used. A speed vs. time recording, as evidence of dynamometer test validity, shall be supplied on request of the Administrator.

(d) Practice runs over the prescribed driving schedule may be performed at test points, provided an emission sample is not taken, for the purpose of finding the minimum throttle action to maintain the proper speed-time relationship, or to permit sampling system adjustments.

NOTE.—When using two-roll dynamometers a truer speed-time trace may be obtained by minimizing the rocking of the vehicle in the rolls. The rocking of the vehicle changes the tire rolling radius on each roll. This rocking may be minimized by restraining the vehicle horizontally (or nearly so) by using a cable and winch.

(e) The drive wheel tires may be inflated up to 45 psig (310 kPag) in order to prevent tire damage. The drive wheel tire pressure shall be reported with the test results.

(f) If the dynamometer has not been operated during the 2 hour period immediately preceding the test it shall be warmed up for 15 minutes by operating at 30 mph (48 kph) using a non-test vehicle or as recommended by the dynamometer manufacturer.

(g) If the dynamometer horsepower must be adjusted manually, it shall be set within 1 hour prior to the exhaust emissions test phase. The test vehicle shall not be used to make this adjustment. Dynamometers using automatic control of preselectable power settings may be set anytime prior to the beginning of the emissions test.

§ 86.132–78 Engine starting and restarting.

(a) *Gasoline fueled vehicles.* Paragraph (a) applies to gasoline fueled vehicles.

(1) The engine shall be started according to the manufacturer's recommended starting procedures. The initial 20 second idle period shall begin when the engine starts.

(2) Choke operation:

(i) Vehicles equipped with automatic chokes shall be operated according to the instructions in the manufacturer's operating instructions or owner's manual including choke setting and "kickdown" from cold fast idle. The transmission shall be placed in gear 15 seconds after the engine is started. If necessary, braking may be employed to keep the drive wheels from turning.

(ii) Vehicles equipped with manual chokes shall be operated according to the manufacturer's operating instructions or owners manual.

(3) The operator may use the choke, accelerator pedal, etc. where necessary to keep the engine running.

(4) If the manufacturer's operating instructions or owner's manual does not specify a warm engine starting procedure, the engine (automatic and manual choke engines) shall be started by depressing the accelerator pedal about half way and cranking the engine until it starts.

(b) *Diesel fueled vehicles.* The engine shall be started according to the manufacturer's recommended starting procedures. The initial 20-second-idle period shall begin when the engine starts. The transmission shall be placed in gear 15 seconds after the engine is started. If necessary, braking may be employed to keep the drive wheels from turning.

(c) If the vehicle does not start after 10 seconds of cranking, cranking shall cease and the reason for failure to start shall be determined. The gas flow measuring device (or revolution counter) on the constant volume sampler (and the hydrocarbon integrator when testing diesel vehicles, see § 86.133, Dynamometer test runs) shall be turned off and the sample selector valves placed in the "standby" position during this diagnostic period. In addition, either the CVS should be turned off or the exhaust tube disconnected from the tailpipe during the diagnostic period.

(1) If failure to start is an operational error, the vehicle shall be rescheduled for testing from a cold start. If failure to start is caused by vehicle malfunction, corrective action of less than 30 minutes duration may be taken and the test continued. The sampling system shall be reactivated at the same time cranking is started. When the engine starts, the driving schedule timing sequence shall begin. If failure to start is caused by vehicle malfunction and the vehicle cannot be started, the test shall be voided, the vehicle removed from the dynamometer, corrective action taken, and the vehicle rescheduled for test. The reason for the malfunction (if determined) and the corrective action taken shall be reported.

(d) If the engine "false starts", the operator shall repeat the recommended starting procedure (such as resetting the choke, etc.)

(e) Stalling:

(1) If the engine stalls during an idle period, the engine shall be restarted immediately and the test continued. If the engine cannot be started soon enough to allow the vehicle to follow the next acceleration as prescribed, the driving sched-

ule indicator shall be stopped. When the vehicle restarts, the driving schedule indicator shall be reactivated.

(2) If the engine stalls during some operating mode other than idle, the driving schedule indicator shall be stopped, the vehicle shall then be restarted and accelerated to the speed required at that point in the driving schedule and the test continued. During acceleration to this point, shifting shall be performed in accordance with § 86.124.

(3) If the vehicle will not restart within 1 minute, the test shall be voided, the vehicle removed from the dynamometer, corrective action taken, and the vehicle rescheduled for test. The reason for the malfunction (if determined) and the corrective action taken shall be reported.

§ 86.133–78 Dynamometer test runs.

(a) The vehicle shall be allowed to stand with the engine turned off for a period of not less than 12 hours or more than 36 hours before the cold start exhaust emission test. The cold start exhaust test shall follow the diurnal breathing loss test by not more than 1 hour. The vehicle shall be stored prior to the emission test in such a manner that precipitation (e.g. rain or dew) does not occur on the vehicle. The complete dynamometer test consists of a cold start drive of 7.5 miles (12.1 km) and simulates a hot start drive of 7.5 miles (12.1 km). The vehicle is allowed to stand on the dynamometer during the 10 minutes time period between the cold and hot start tests. The cold start test is divided into two periods. The first period, representing the cold start "transient" phase, terminates at the end of the deceleration which is scheduled to occur at 505 seconds of the driving schedule. The second period, representing the "stabilized" phase, consists of the remainder of the driving schedule including engine shutdown. The hot start test similarly consists of two periods. The period, representing the hot start "transient" phase, terminates at the same point in the driving schedule as the first period of the cold start test. The second period of the hot start test, "stabilized" phase, is assumed to be identical to the second period of the cold start test. Therefore, the hot start test terminates after the first period (505 seconds) is run.

(b) The following steps shall be taken for each test:

(1) Place drive wheels of vehicle on dynamometer without starting engine.

(2) Open the vehicle engine compartment cover and position the cooling fan.

(3) With the sample selector valves in the "standby" position connect evacuated sample collection bags to the two dilute exhaust and two dilution air sample collection systems.

(4) Start the Constant Volume Sampler (if not already on), the sample pumps, the temperature recorder, the vehicle cooling fan and the heated hydrocarbon analysis recorder (diesel only). (The heat exchanger of the constant volume sampler, if used, diesel hydrocarbon analyzer continuous sample line and filter (if applicable) should be preheated to their respective operating temperatures before the test begins.)

(5) Adjust the sample flow rate to the desired flow rate (minimum of 10 cfh, 0.28 m^3/hr) and set the gas flow measuring devices to zero.

NOTE.—CFV–CVS sample flowrate is fixed by the venturi design.

(6) Attach the flexible exhaust tube to the vehicle tailpipe(s).

(7) Start the gas flow measuring device, position the sample selector valves to direct the sample flow into the "transient" exhaust sample bag and the "transient" dilution air sample bag, (turn on the diesel hydrocarbon analyzer system integrator and mark the recorder chart, if applicable) and start cranking the engine.

(8) Fifteen seconds after the engine starts, place the transmission in gear.

(9) Twenty seconds after the engine starts, begin the initial vehicle acceleration of the driving schedule.

(10) Operate the vehicle according to the dynamometer driving schedule (§ 86.113).

(11) At the end of the deceleration which is scheduled to occur at 505 seconds, simultaneously switch the sample flows from the "transient" bags to the "stabilized" bags, switch off gas flow measuring device No. 1 (and the diesel hydrocarbon integrator No. 1, mark the diesel hydrocarbon recorder chart) and start gas flow measuring device No. 2 (and diesel hydrocarbon integrator No. 2). As soon as possible, and in no case longer than 20 minutes after the end of this portion of the test, transfer the "transient" exhaust and dilution air sample bags, to the analytical system and process the samples according to § 86.135.

(12) Turn the engine off 2 seconds after the end of the last deceleration (at 1,369 seconds).

(13) Five seconds after the engine stops running, simultaneously turn off gas flow measuring device No. 2 (and the diesel hydrocarbon integrator No. 2, mark the hydrocarbon recorder chart, if applicable) and position the sample selector valves to the "standby" position. As soon as possible, and in no case longer than 20 minutes after the end of this portion of the test, transfer the "stabilized" exhaust and dilution air sample bags, to the analytical system and process the samples according to § 86.135.

(14) Immediately after the end of the sample period turn off the cooling fan and close the engine compartment cover.

(15) Turn off the CVS or disconnect the exhaust tube from the tailpipe of the vehicle.

(16) Repeat the steps in paragraph (b)(2) through (10) of this section for the hot start test, except only one evacuated sample bag is required for sampling exhaust gas and one for dilution air. The step in paragraph (b)(7) of this section shall begin between 9 and 11 minutes after the end of the sample period for the cold start test.

(17) At the end of the deceleration which is scheduled to occur at 505 seconds, simultaneously turn off gas flow measuring device No. 1 (and diesel hydrocarbon integrator No. 1, mark the diesel hydrocarbon recorder chart, if applicable) and position the sample selector valve to the "standby" position. (Engine shutdown is not part of the hot start test sample period.)

(18) As soon as possible, and in no case longer than 20 minutes after the end of this portion of the test transfer the hot start "transient" exhaust and dilution air sample bags, to the analytical system and process the samples according to § 86.135.

(19) Disconnect the exhaust tube from the vehicle tailpipe(s) and drive vehicle from dynamometer.

(20) The constant volume sampler may be turned off, if desired.

(21) Vehicles to be tested for evaporative emissions will proceed according to § 86.134. For all others this completes the test sequence.

§ 86.134–78 Hot soak test.

The hot soak evaporative emission test shall be conducted immediately following the hot transient exhaust emission test.

(a) Prior to the completion of the hot start transient exhaust emission sampling period, the evaporative emission enclosure shall be purged for several minutes.

(b) The FID hydrocarbon analyzer shall be zeroed and spanned immediately prior to the test.

(c) If not already on, the evaporative enclosure mixing fan shall be turned on at this time.

(d) Upon completion of the hot transient exhaust emission sampling period, the vehicle engine compartment cover shall be closed, the cooling fan shall be moved, the vehicle shall be disconnected from the dynamometer and exhaust sampling system and then driven at minimum throttle to within 10 feet (3.3 m) of the vehicle entrance to the enclosure.

(e) The test vehicle windows and luggage compartments shall be opened.

(f) The temperature recording system shall be started.

(g) The vehicle's engine shall be shut off and the vehicle shall be pushed into the enclosure. The time of engine shutoff shall be noted on the evaporative emission hydrocarbon data recording system.

(h) The enclosure doors shall be closed and sealed within one minute of engine shutdown and within five minutes after the end of the exhaust test.

(i) The 60 ± 0.5 minutes hot soak begins when the enclosure doors are sealed. The enclosure atmosphere shall be analyzed and recorded. This is the initial (time=0 minutes) hydrocarbon concentration, C_{HC_i}, for use in calculating evaporative losses, see § 86.137.

(j) The test vehicle shall be permitted to soak for a period of at least one hour in the enclosure.

(k) The FID hydrocarbon analyzer shall be zeroed and spanned immediately prior to the end of the test.

(l) At the end of the 60 ± 0.5 minute test period, again analyze the enclosure atmosphere and record time. This is the

final (time=60 minutes) hydrocarbon concentration, C_{HCf}, for use in calculating evaporative losses, see § 86.137. This operation completes the evaporative emission measurement procedure.

§ 86.135–78 Exhaust sample analysis.

The following sequence of operations shall be performed in conjunction with each series of measurements:

(a) Zero the analyzers and obtain a stable zero reading. Recheck after tests.

(b) Introduce span gases and set instrument gains. In order to avoid corrections, span and calibrate at the same flow rates used to analyze the test sample. Span gases should have concentrations equal to approximately 80 percent of full scale. If gain has shifted significantly on the analyzers, check the calibrations. Show actual concentrations on chart.

(c) Check zeros; repeat the procedure in paragraphs (a) and (b) of this section if required.

(d) Check flowrates and pressures.

(e) Measure HC, CO, CO_2 and NOx concentrations of samples.

(f) For diesel vehicles, continuously record (integrate electronically if desired) dilute hydrocarbon emission levels during test. Background samples are collected in sample bags and analyzed as above.

(g) Check zero and span points. If difference is greater than 2% of full scale, repeat the procedure in paragraphs (a) through (f).

§ 86.136–78 Records required.

The following information shall be recorded with respect to each test:

(a) Test number.

(b) System or device tested (brief description).

(c) Date and time of day for each part of the test schedule.

(d) Instrument operator.

(e) Driver or operator.

(f) Vehicle: Make, Vehicle identification number, Model year, Transmission type, Odometer reading, Engine displacement, Engine family, Evap. family, Idle rpm, Fuel system (fuel injection, nominal fuel tank(s) capacity, fuel tank(s) location, number of carburetors, number of carburetor barrels), Inertia loading, Actual curb weight recorded at 0 miles, Actual road load at 50 mph (80 kph) and drive wheel tire pressure, as applicable.

(g) Indicated road load power absorption at 50 mph (80 kph) and dynamometer serial number. As an alternative to recording the dynamometer serial number, a reference to a vehicle test cell number may be used, with the advance approval of the Administrator, provided the test cell records show the pertinent information.

(h) All pertinent instrument information such as tuning, gain, serial number, detector number, range. As an alternative, a reference to a vehicle test cell number may be used, with the advance approval of the Administrator, provided test cell calibration records show the pertinent instrument information.

(i) Recorder charts: Identify zero, span, exhaust gas, and dilution air sample traces.

(j) Test cell barometer pressure, ambient temperature and humidity.

NOTE.—A central laboratory barometer may be used; provided that individual test cell barometric pressures are shown to be within ±0.1 percent of the barometric pressure at the central barometer location.

(k) Fuel temperatures, as prescribed.

(l) Pressure of the mixture of exhaust and dilution air entering the CVS metering device, the pressure increase across the device, and the temperature at the inlet. The temperature may be recorded continuously or digitally to determine temperature variations.

(m) The number of revolutions of the positive displacement pump accumulated during each test phase while exhaust samples are being collected. The number of standard cubic feet metered by a critical flow venturi during each test phase would be the equivalent record for a CFV–CVS.

(n) The humidity of the dilution air.

NOTE.—If conditioning columns are not used (see § 86.119 and § 86.138) this measurement can be deleted. If the conditioning columns are used and the dilution air is taken from the test cell, the ambient humidity can be used for this measurement.

(o) Temperature set point of the heated sample line and heated hydrocarbon detector temperature control system (for diesel vehicles only).

§ 86.137–78 Calculations; evaporative emissions.

The calculation of the net hydrocarbon mass change in the enclosure is used to determine the diurnal and hot soak mass emissoins. The mass is calculated from initial and final hydrocarbon concentrations in ppm carbon, initial and final enclosure ambient temperatures, initial and final barometric pressures, and net enclosure volume using the following equation:

$$M_{HC} = k\,V_n \times 10^{-4}\left[\frac{C_{HCf}\,P_{Bf}}{T_f} - \frac{C_{HCi}\,P_{Bi}}{T_i}\right]$$

Where:

M_{HC} = Hydrocarbon mass, g.

C_{HC} = Hydrocarbon concentration as ppm carbon.

V_n = Net enclosure volume, ft^3 (m^3) as determined by subtracting 50 ft^3 (1.42 m^3) (volume of vehicle with trunk and windows open) from the enclosure volume.

P_B = Baremetric pressure, in. Hg (kPa).

T = Enclosure ambient temperature, R (K).

k = .208 (12+H/C)

for SI units, k = 1.2 (12+H/C).

Where:

H/C = Hydrogen-carbon ratio.

H/C = 2.33 for diurnal emissions.

H/C = 2.2 for hot soak emissions.

i = Indicates initial reading.

f = Indicates final reading.

§ 86.138–78 Calculations; exhaust emissions.

The final reported test results shall be computed by use of the following formula:

(a) For light duty vehicles and light duty trucks:

$$Y_{wm} = (0.43\,Y_{ct} + 0.57\,Y_{ht} + Y_s)/7.5$$

Where:

Y_{wm} = Weighted mass emissions of each pollutant, i.e., HC, CO, or NOx, in grams per vehicle mile.

Y_{ct} = Mass emissions as calculated from the "transient" phase of the cold start test, in grams per test phase.

Y_{ht} = Mass emissions as calculated from the "transient" phase of the hot start test, in grams per test phase.

Y_s = Mass emissions as calculated from the "stabilized" phase of the cold start test, in grams per test phase.

(b) The mass of each pollutant for each phase of both the cold start test and the hot start test is determined from the following:

(1) Hydrocarbon mass:

$HC_{mass} = V_{mix} \times Density_{HC} \times (HC_{conc}/1{,}000{,}000)$

(2) Oxides of nitrogen mass:

$NOX_{mass} = V_{mix} \times Density_{NO_2} \times K_H \times (Nox_{conc}/1{,}000{,}000)$

(3) Carbon monoxide mass:

$CO_{mass} = V_{mix} \times Density_{CO} \times (CO_{conc}/1{,}000{,}000)$

(4) Carbon dioxide mass:

$CO_{2mass} = V_{mix} \times Density_{CO_2} \times CO_{2conc}/100)$

(c) Meaning of symbols:

(1) HC_{mass} = Hydrocarbon emissions, in grams per test phase.

$Density_{HC}$ = Density of hydrocarbons is 16.33 g/ft^3 (.5767 kg/m^3), assuming an average carbon to hydrogen ratio of 1:1.85, at 68°F (20°C) and 760 mm Hg (101.3 kPa) pressure.

HC_{conc} = Hydrocarbon concentration of the dilute exhaust sample corrected for background, in ppm carbon equivalent, i.e., equivalent propane X 3.

$HC_{conc} = HC_e - HC_d(1-1/DF)$

Where:

HC_e = Hydrocarbon concentration of the dilute exhaust sample or, for diesel, average hydrocarbon concentration of the dilute exhaust sample as calculated from the integrated HC traces, in ppm carbon equivalent.

HC_d = Hydrocarbon concentration of the dilution air as measured, in ppm carbon equivalent.

(2) NOx_{mass} = Oxides of notrogen emissions, in grams per test phase.

$Density_{NO_2}$ = Density of oxides of nitrogen is 54.16 g/ft^3 (1.913 kg/m^3), assuming they are in the form of nitrogen dioxide, at 68° F (20° C) and 760 mm Hg (101.3 kPa) pressure.

NOx_{conc} = Oxides of nitrogen concentration of the dilute exhaust sample corrected for background, in ppm.

$NOx_{conc} = NOx_e - NOx_d\ (1-1/DF)$

Where:

NOx_e = Oxides of nitrogen concentration of the dilute exhaust sample as measured, in ppm.

NOx_d = Oxides of nitrogen concentration of the dilute air as measured, in ppm.

(3) CO_{mass} = Carbon monoxide emisisons, in grams per test phase.

$Density_{CO}$ = Density of carbon monoxide is 32.97 g/ft^3 (1.164 kg/m^3), at 68° F (20° C) and 760 mm Hg (101.3 kPa) pressure.

CO_{conc} = Carbon monoxide concentration of the dilute exhaust sample corrected for background, water vapor, and CO_2 extraction, in ppm.

$CO_{conc} = CO_e - CO_d\ (1-1/DF)$

Where:

CO_e = Carbon monoxide concentration of the dilute exhaust sample volume corrected for water vapor and carbon dioxide extraction, in ppm. The calculation asumes the carbon to hydrogen ratio of the fuel is 1:1.85.

$CO_e = (1-0.01925\,CO_{2e} - 0.000323\,R)\ CO_{em}$

Where:

CO_{em} = Carbon monoxide concentration of the dilute exhaust sample as measured, in ppm.

CO_{2e} = Carbon dioxide concentration of the dilute exhaust sample, in percent.

R = Relative humidity of the dilution air, in percent (see § 86.136-78(n)).

CO_d = Carbon monoxide concentration of the dilution air corrected for water vapor extraction, in ppm.

$CO_d = (1-0.000323\ R)\ CO_{dm}$

Where:

CO_{dm} = Carbon monoxide concentration of the dilution air sample as measured, in ppm.

NOTE.—If a CO instrument which meets the criteria specified in § 86.110 is used and the conditioning column has been deleted, CO_{em} can be substituted directly for CO_e and CO_{dm} can be substituted directly for CO_d.

(4) CO_{2mass} = Carbon dioxide emissions, in grams per test phase.

$Density CO_2$ = Density of carbon dioxide is 51.85 g/ft³ (1.843 kg/m³), at 68° F (20° C) and 760 mm Hg (101.3 kPa) pressure.

CO_{2conc} = Carbon dioxide concentration of the dilute exhaust sample corrected for background, in percent.

$CO_{2conc} = CO_{2e} - CO_{2d}\ (1-1/DF)$

Where:

CO_{2d} = Carbon dioxide concentration of the dilution air as measured, in percent.

(5) $DF = 13.4/[CO_{2e} + (HC_e + CO_e)\,10^{-4}]$

K_H = Humidity correction factor.

$K_H = 1/[1-0.0047\ (H-75)]$

for SI units $= 1/[1-0.033\ (H-10.7)]$

Where:

H = Absolute humidity in grains (grams) of water per pound (kilogram) of dry air.

$H = [(43.478)\ R_a \times P_d]/[P_B - (P_d \times R_a/100)]$

for SI units, $H = [(6.0266) R_a \times P_d]/[P_B - (P_d \times R_a/100)]$

R_a = Relative humidity of the ambient air, in percent.

P_d = Saturated vapor pressure, in mm Hg (kPa) at the ambient dry bulb temperature.

P_B = Barometric pressure, in mm Hg (kPa).

V_{mix} = Total dilute exhaust volume in cubic feet per test phase corrected to standard conditions (528 R (293 K) and 760 mm Hg (101.3 kPa)).

For PDP-CVS, V_{mix} is:

$$V_{mix} = V_o \times \frac{N(P_B - P_d)\,(528\ R)}{(760\ mm\ Hg)\ (T_p)}$$

for SI units, $V_{mix} = V_o \times \frac{N(CP_B - P_d)\ (293.15\ K)}{(101.325\ kPa)\ (T_p)}$

Where:

V_o = Volume of gas pumped by the positive displacement pump, in cubic feet (m³) per revolution. This volume is dependent on the pressure differential across the positive displacement pump.

N = Number of revolutions of the positive displacement pump during the test phase while samples are being collected.

P_B = Barometric pressure, in mm Hg (kPa).

P_d = Pressure depression below atmospheric measured at the inlet to the positive displacement pump, in mm Hg (kPa).

T_p = Average temperature of dilute exhaust entering positive displacement pump during test, R(K).

(d) Example caculation of mass values of exhaust emissions using positive displacement pump:

(1) For the "transient" phase of the cold start test assume the following:

$V_o = 0.29344$ ft³/revolution; $N = 10{,}485$; $R = 48.0\%$; $R_a = 48.2\%$; $P_B = 762$ mm Hg; $P_d = 22.225$ mm Hg; $P_4 = 70$ mm Hg; $T_p = 570$ R; $HC_e = 105.8$ ppm, carbon equivalent; $NOx_e = 11.2$ ppm; $CO_{em} = 306.6$ ppm; $CO_{2e} = 1.43\%$; $HC_d = 12.1$ ppm; $NOx_d = 0.8$ ppm; $CO_{dm} = 15.3$ ppm.

Then:

$V_{mix} = (0.29344)\ (10{,}485)\ (762-70)\ (528)/(760)\ (570) = 2595.0$ ft³ per test phase.

$H = (43.478)\ (48.2)\ (22.225)/[762 - (22.225 \times 48.2/100)]$

$K_H = 1/[1-0.0047\ (62-75)] = 0.9424$

$CO_e = [1-0.01925\ (1.43) - 0.000323\ (48)]\ 306.0 = 293.4$ ppm

$CO_d = [1-0.000323\ (48)]\ 15.3 = 15.1$ ppm

$DR = 13.4/[1.43 + (105.8+283.4) \times 10^{-4}] = 9.11$

$HC_{conc} = 105.8 - 12.1\ (1-1/9.116) = 95.03$ ppm

$HC_{mass} = (2595)\ (16.33)\ (95.03/1{,}000{,}000) = 4.027$ grams per test phase.

$NOx_{conc} = 11.2 - 0.8\ (1-1/9.116) = 10.49$ ppm

$NOx_{mass} = (2595)\ (54.16)\ (10.49/1{,}000{,}000)\ (0.9424) = 1.389$ grams per test phase.

$CO_{conc} = 293.4 - 15.1\ (1-1/9.116) = 280.0$ ppm

$CO_{mass} = (2595)\ (32.97)\ (280/1{,}000{,}000) = 23.96$ grams per test phase.

(2) For the stabilized portion of the cold start test assume that similar calculations resulted in the following:

$HC_{mass} = 0.62$ grams per test phase

$NOx_{mass} = 1.27$ grams per test phase

$CO_{mass} = 5.98$ grams per test phase

(3) For the "transient" portion of the hot start test assume that similar calculations resulted in the following:

$HC_{mass} = 0.51$ grams per test phase

$NOx_{mass} = 1.38$ grams per test phase

$CO_{mass} = 5.01$ grams per test phase

(4) Weighted mass emission results:

$HC_{wm} = [(0.43)\ (4.027) + (0.57)\ (0.51) + 0.62]/7.5 = 0.352$ grams per vehicle mile.

$NOx_{wm} = [(0.43)\ (1.389) + (0.57)\ (1.38) + 1.27]/7.5 = 0.354$ grams per vehicle mile.

$CO_{wm} = [(0.43\ (23.96) + (0.57)\ (5.01) + 5.98]/7.5 = 2.55$ grams per vehicle mile.

[FR Doc.76-579 Filed 1-12-76;8:45 am]